5 100-KR

5.1 Overview

The 100-KR groundwater interest area includes the 100-KR-4 OU and an adjacent region to the east. Groundwater in 100-KR was contaminated by waste releases associated with past operations of the KE and KW Reactors and from associated support facilities. At the end of 2014, approximately 59 percent of the waste sites were classified as closed, interim closed, no action, or not accepted or rejected, with approximately 37 percent having undergone active remediation. Removing contaminants from the vadose zone eliminates secondary sources of contamination that could migrate to groundwater and reduces the risk of direct exposure at the surface.

Table 5-1 lists key facts about 100-KR. Additional details about 100-KR history, waste sites, and hydrogeology are provided in Chapters 1 and 3 of the RI/FS for the K Reactor area source and groundwater OUs (DOE/RL-2010-97, Draft A). Waste sites known or suspected to have contributed to observed groundwater contamination at 100-KR include 183-KE and 183-KW Head House tank farms, 116-KE-1 and 116-KW-1 Gas Condensate Cribs, 116-KE-3 and 116-KW-2 Fuel Storage Basin Cribs/Reverse Wells, 116-K-1 Crib, 116-K-2 Trench, and 118-K-1 Burial Ground. Figure 5-1 shows the locations of key features in 100-KR and the inferred groundwater elevation contours generated from the measurements collected in March 2014. Section 1.3 provides plume mapping details, including descriptions of terms in figure legends (e.g., Type 1 Control Point).

The unconfined aquifer in 100-KR ranges from 5.2 to more than 32 m (17.1 to 105 ft) thick. This aquifer is primarily present in the Ringold Formation unit E sand and gravel (Figure 5-2). This unit is overlain by the gravels and interbedded sand and silt of the Hanford formation, which comprise the bulk of the vadose zone. The vadose zone ranges from less than 1 m (3.3 ft) thick near the Columbia River to 32 m (105 ft) thick inland. The uneven surface of the silt- and clay-rich RUM forms the bottom of the unconfined aquifer. Contaminant concentrations are generally highest within the uppermost portion of the aquifer near the water table, however, mobile contaminants (e.g., hexavalent chromium) have been detected over the entire aquifer thickness, particularly near source areas.

Groundwater in 100-KR flows generally to the northwest toward the Columbia River, which forms a discharge boundary for the unconfined aquifer. Operation of P&T systems at 100-KR creates changes in groundwater flow direction and velocity. These changes are expressed as depressions and mounds in the water table, affecting the flow direction (Figure 5-1). Larger mounds, such as that produced by the combined discharges from the KR4 and KX systems near the middle of the 116-K-2 Trench, create conditions of radial flow away from the mound. This creates local diversion of groundwater flow direction away from the natural patterns. Groundwater further inland of the 100-K Area generally flows to the north and northeast toward the 100-N and 100-D Areas. The actual flow direction and apparent velocity in this inland area is somewhat uncertain due to sparse groundwater elevation measurements in the area.

Daily and seasonal fluctuations in the river stage also affect groundwater flow in 100-KR. As would be expected, longer term changes in the river stage produce more extensive and longer lived changes in the water levels, hydraulic gradient, and flow directions in the unconfined aquifer. Intrusion of river water into the aquifer during high river stage can lower contaminant concentrations in aquifer tubes and in some near river wells. The highest river stage in 2014 was observed in the first week of June and the first week of July. Low river-stage periods for calendar year 2014 were observed from January through February and from late August through December. The peak river stage elevation observed in 2014 (i.e., about 121.2 m [397.6 ft] above mean sea level [amsl]) was similar to the peak observed in 2013.

Table 5-1. 100-KR at a Glance

Reactor operations: KE, 1955–1971; KW, 1955–1970				
2014 Groundwater Monitoring				
Contaminant	**Water Quality Standard[a]**	**Maximum Concentration**	**Plume Area[b] (km^2)**	**Shoreline Impact[c] (m)**
Hexavalent chromium	10 µg/L[d]	3,280 µg/L (199-K-205)[e]	2.1[f]	200
Tritium	20,000 pCi/L	414,000 pCi/L (199-K-207)	0.15	0
Nitrate	45 mg/L	74 mg/L (199-K-210)	0.01	0
Strontium-90	8 pCi/L	13,200 pCi/L[g]	0.03	0
Carbon-14	2,000 pCi/L	39,500 pCi/L[g]	0.04	0
TCE	5 µg/L	6.8 µg/L (199-K-185)	0.01	0
Remediation				
Waste sites (interim action): ~ 59 percent complete[h]				
Groundwater remediation (interim ROD for hexavalent chromium): • KR4 P&T: 1997–2014, removed 373 kg • KW P&T: 2007–2014, removed 224 kg • KX P&T: 2009–2014, removed 200 kg Final ROD anticipated after 2015.				

a. Drinking water standard for all but hexavalent chromium

b. Estimated area at a concentration greater than the listed water quality standard.

c. Length of shoreline at 100-KR that is not considered to be "protected" against potential for continuing release of hexavalent chromium to the river. Other contaminant plumes do not intersect the river at concentrations above standards, based on data from wells and aquifer tubes.

d. The applicable standard is the 10 µg/L surface water quality criterion. A 20 µg/L groundwater interim action cleanup target for inland groundwater was identified in RD/RA Work Plan (DOE/RL-96-84) for interim remedial action based on an assumed 1:1 dilution of groundwater entering the river. The interim remedial action objective remains to protect the Columbia River against releases that would cause exceedance of the 10 µg/L surface water quality criterion.

e. January 2014 sample collected during drilling of new well.

f. Based on a concentration greater than the 10 µg/L surface water quality criterion. This area includes the plume within the 100-KR interest area plus approximately 0.2 km^2 of additional chromium within the 100-NR and 100-FR interest areas that is apparently attributable to 100-KR historical operations is located within 100-NR interest area. The groundwater plume area exceeding the interim groundwater target concentration of 20 µg/L at 100-K is 0.76 km^2/0.29 $mi^{2.}$

g. Maximum based on estimated migration of historical plumes.

h. Sites with status of closed, interim closed, no action, not accepted, or rejected.

ROD = Record of Decision
TCE = Trichloroethene

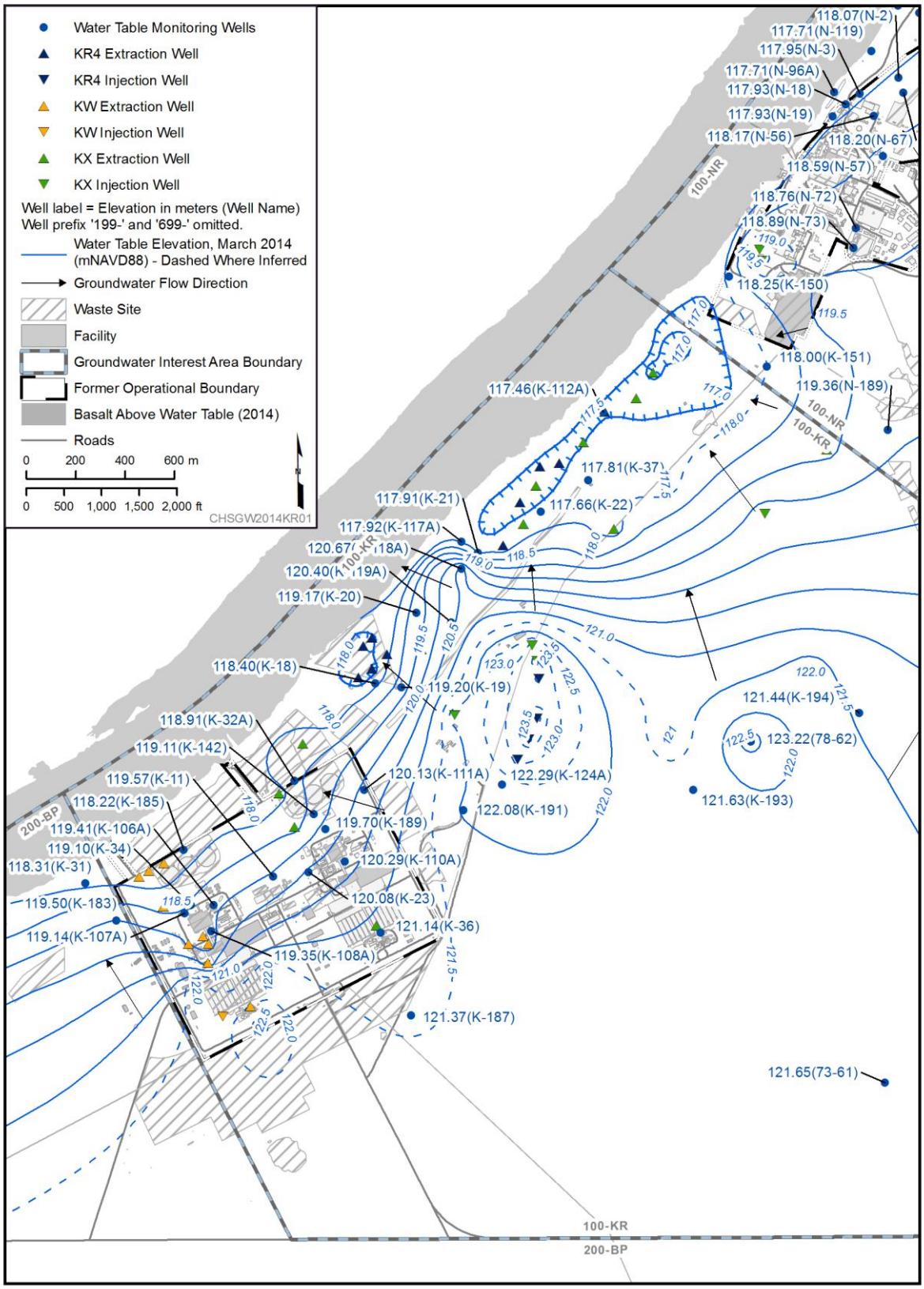

Figure 5-1. 100-KR Overview Map with 2014 Water Table

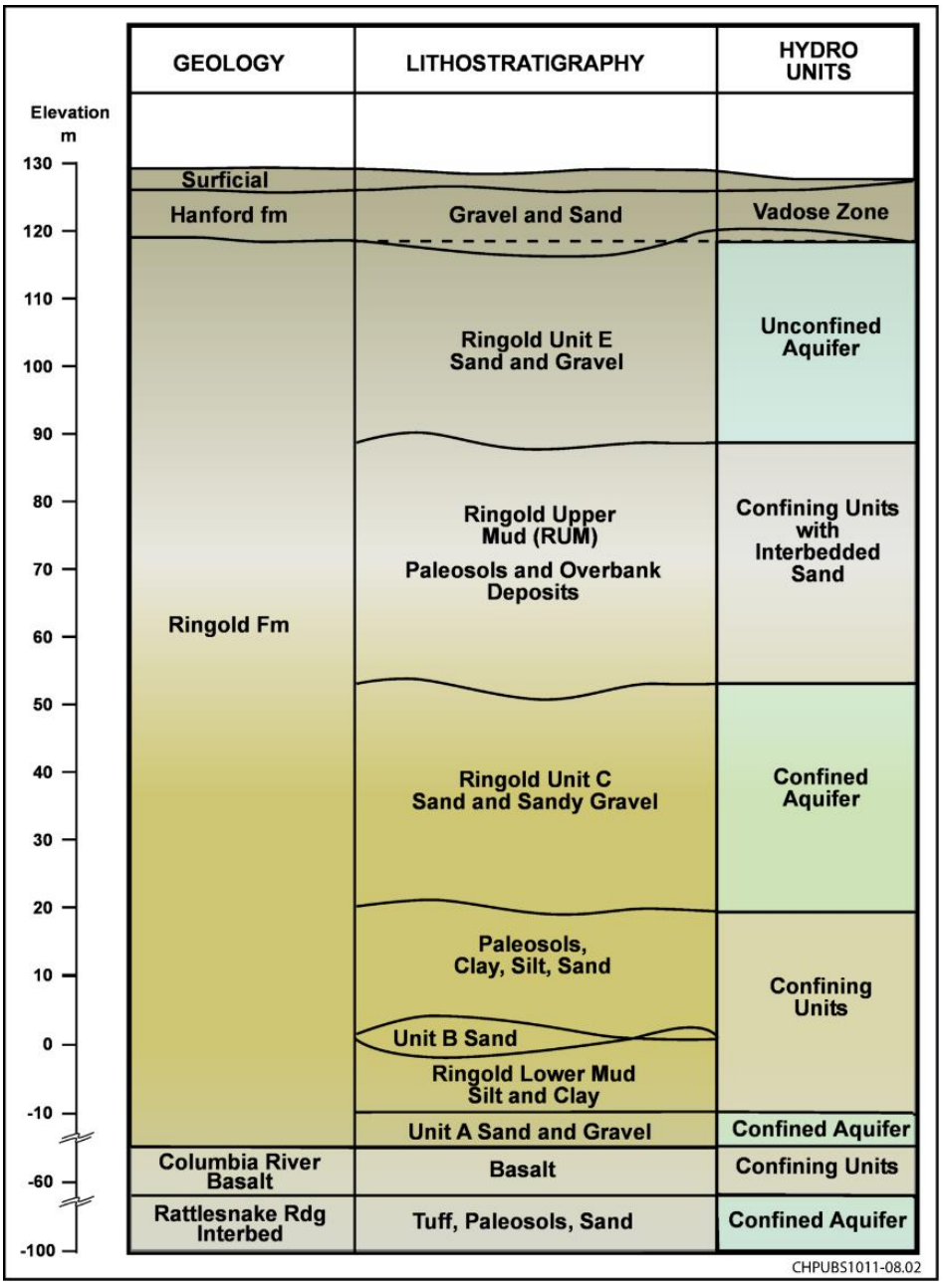

Figure 5-2. 100-KR Geology

Contaminants in the 100-KR unconfined aquifer were identified in the RI/FS and include chromium (total and hexavalent), tritium, nitrate, strontium-90, carbon-14, and TCE. Figure 5-3 shows how the plume areas have changed since 2003. Chromium in groundwater at some locations has historically been measured as total chromium (in filtered and/or unfiltered aliquots), instead of, or in addition to, hexavalent chromium. Anthropogenic chromium in groundwater at 100-KR is understood to be present as hexavalent chromium and so total chromium in filtered aliquots and hexavalent chromium are discussed as hexavalent chromium for purposes of this report.

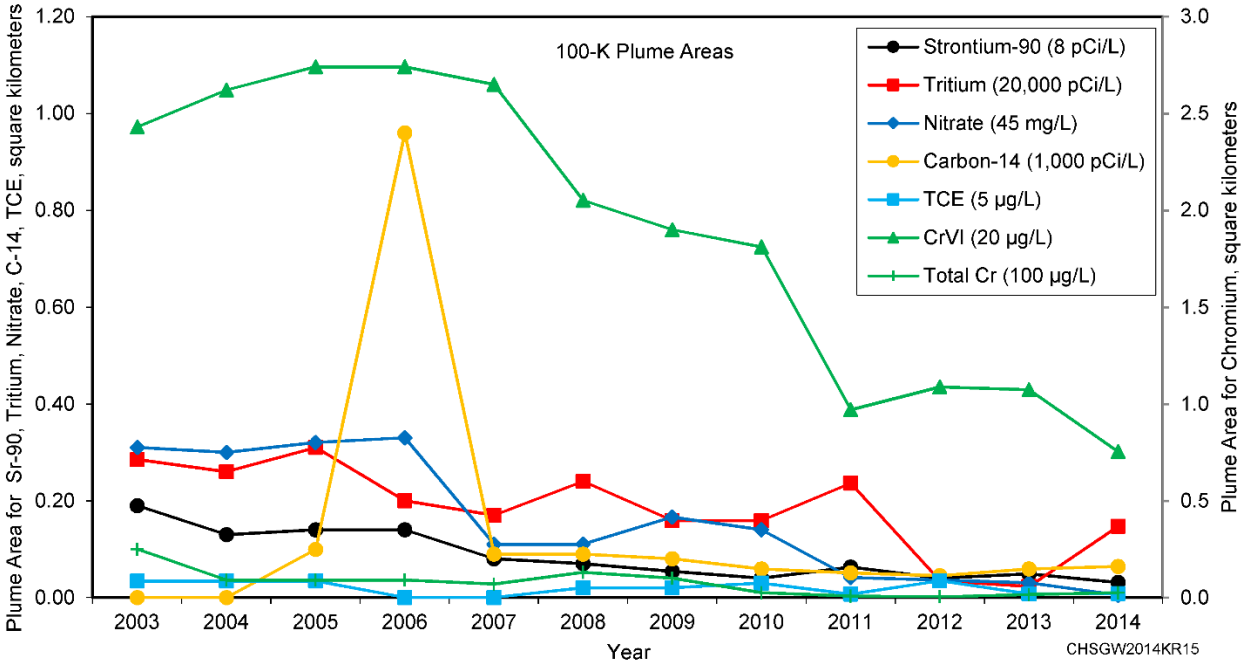

Figure 5-3. Changes in Selected Plume Areas since 2003 at 100-KR-4 OU

5.2 CERCLA Activities

CERCLA groundwater activities in 100-KR included groundwater sampling and analysis at monitoring well locations and operation of three interim groundwater remediation systems focusing on removal of hexavalent chromium (Figure 5-4; Table A-3 of Appendix A). CERCLA groundwater sampling includes monitoring interim remedial actions for effectiveness and monitoring wells throughout 100-KR to track contamination. Additional groundwater samples are collected and analyzed for identified co-contaminants of carbon-14, nitrate, strontium-90, TCE, and tritium, which are discussed separately. These constituents, which have been identified as groundwater COCs through the RI/FS process, may be captured and extracted incidentally by the interim remedial action system. They are not, however, treated by the interim action and are, therefore, considered to be co-contaminants of the hexavalent chromium, which is the primary target of the interim action. Another contaminant related to historical reactor operations at 100-KR is technetium-99. Technetium-99 is detected in groundwater within 100-KR at concentrations consistently less than 100 pCi/L, which is much less than the DWS equivalent concentration of 900 pCi/L. Technetium-99 has not been identified as a COC at 100-K.

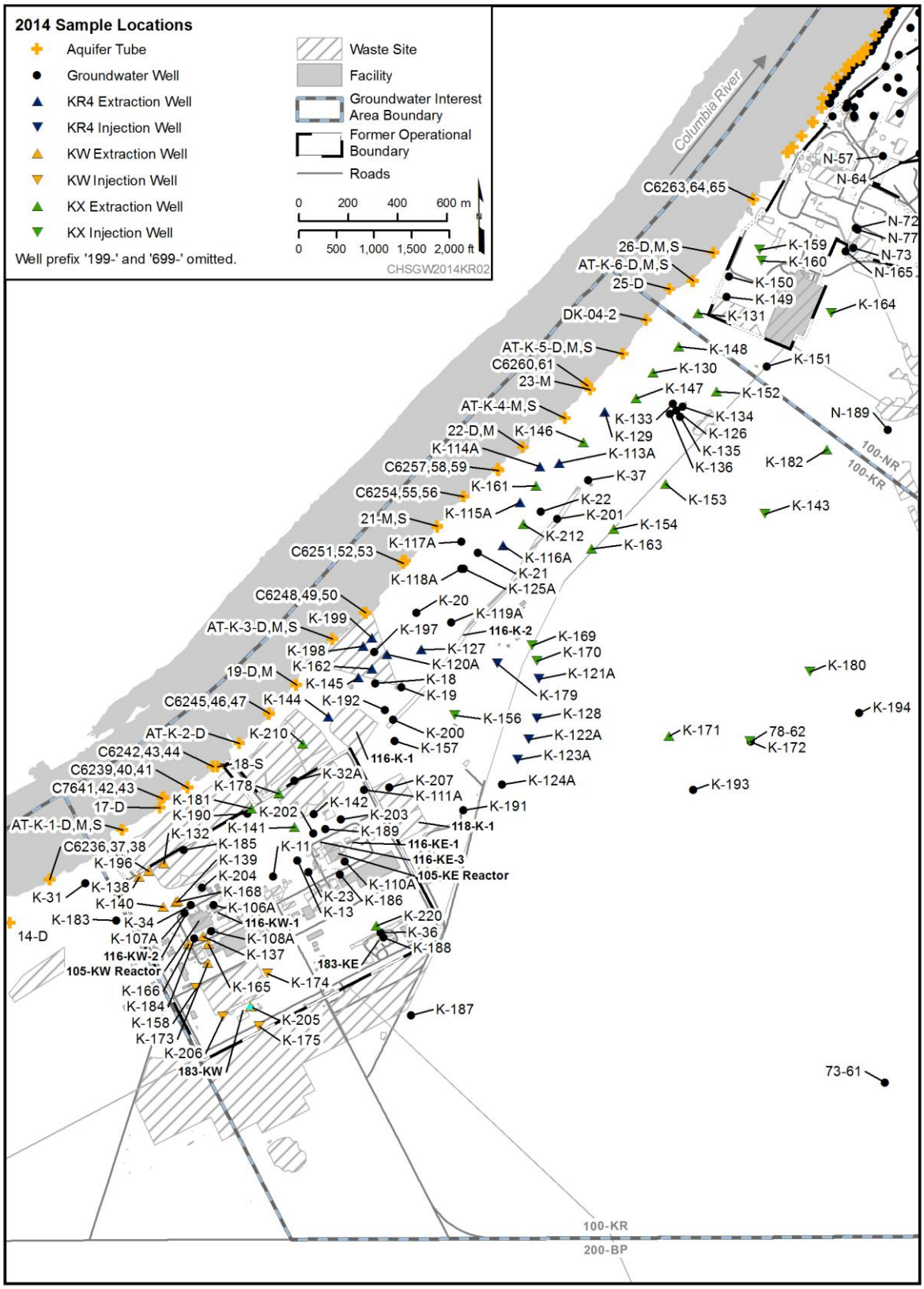

Figure 5-4. 100-KR Sampling Locations, 2014

Petroleum hydrocarbons (measured as total petroleum hydrocarbons, or TPH) have been encountered in the vadose zone during the drilling of Wells 199-K-167 (decommissioned), 199-K-173, and 199-K-186. Low levels of petroleum hydrocarbons (all less than 100 µg/L of diesel-range hydrocarbons) were detected in groundwater during 2014 at five locations. Detections of TPH were in one location in the vicinity of 105-KE and the other four were in the vicinity of 105-KW. All detections were downgradient of the reactor underground fuel oil storage tanks.

100-KR aquifer tubes are generally scheduled for annual sampling in the fall; this provides information about conditions near the river during the period of most rapid movement of groundwater toward the river. Aquifer tubes (described in Appendix C) provide samples of water from the near-river environment and hyporheic zone. Analysis of near-river samples provides information on conditions in potential exposure points for aquatic organisms. Seventy one samples were collected from 100-KR aquifer tubes during 2014.

As of December 2014, 41 extraction wells and 18 injection wells were in use for P&T groundwater remediation operations. Combined, the three systems are capable of treating more than 7.9 million L (2.1 million gal) of groundwater per day. The combined P&T systems in 100-KR removed 50 kg of hexavalent chromium from groundwater in 2014. Since 1997, the P&T systems have removed 797 kg of hexavalent chromium from the aquifer. Section 5.10 of this chapter provides additional information, and *Calendar Year 2014 Annual Summary Report for the 100-HR-3 and 100-KR-4 Pump-and-Treat Operations, and 100-NR-2 Groundwater Remediation* (DOE/RL-2015-05) provides details.

5.2.1 Remedial Investigation/Feasibility Study

DOE submitted Draft A of an RI/FS (DOE/-RL-2010-97, Draft A) and Proposed Plan (DOE/RL-2011-82, Draft A) to EPA in 2011. EPA reviewed the documents in 2012, and DOE will incorporate the results of supplemental source characterization activities upon completion of additional investigation activities. The RI/FS report presents results of RI studies and evaluates alternatives for cleanup of the vadose zone and groundwater. Based on the observed efficacy of P&T systems at 100-KR-4 OU, it seems likely that the proposed plan for this OU will include P&T as a major element of a preferred alternative.

5.3 Hexavalent Chromium – Low River Stage

Hexavalent chromium is a mobile contaminant at 100-KR, and its presence resulted from historical releases of two different types of wastewater contaminated with chromium. The first type of release included spills, leaks, and limited intentional discharge of concentrated sodium dichromate dihydrate solutions used as feed chemicals for conditioning reactor cooling water. The second type of release included spent reactor cooling water from retention basin leaks and intentional discharges to the 116-K-1 Crib and 116-K-2 Trench. The plumes from these sources are associated with three general areas: (1) a plume originating at, or near, the 183-KW Head House chemical storage tank farm and extending riverward; (2) a plume originating at, or near, the 183-KE Head House chemical storage tank farm and extending riverward; and (3) a plume originating at the 116-K-1 Crib and 116-K-2 Trench and extending radially away from those sites. These plumes have been reshaped and/or dissected by operation of the groundwater P&T systems at 100-K (Figures 5-5 and 5-6), which substantially reduced the observed groundwater hexavalent chromium concentrations since 1996. Based on aquifer tube sampling and near-river wells, the extent of hexavalent chromium at the river shore continues to decline.

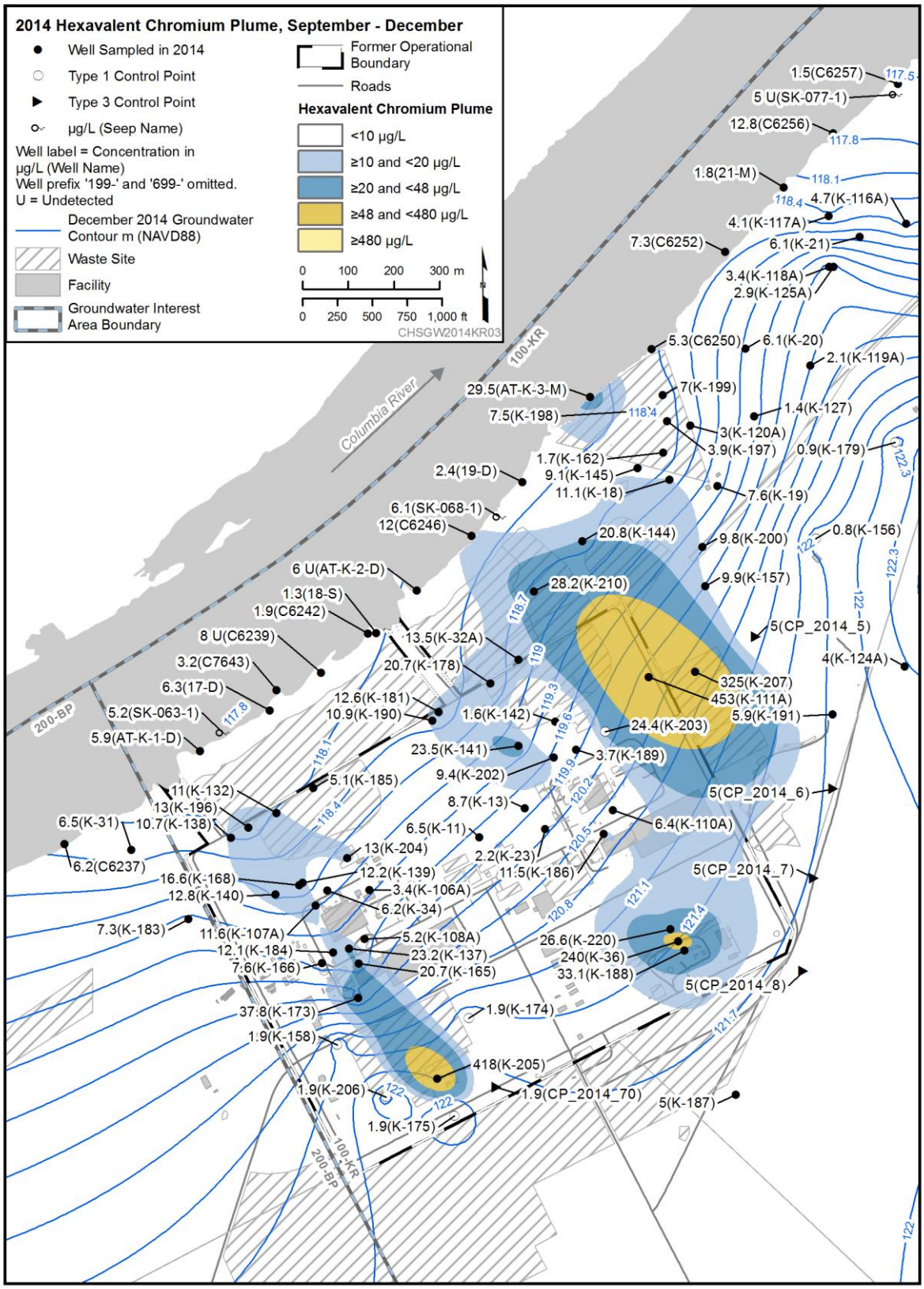

Figure 5-5. 100-KR Hexavalent Chromium Plume (Low River Stage), KE and KW Reactor Vicinity, 2014

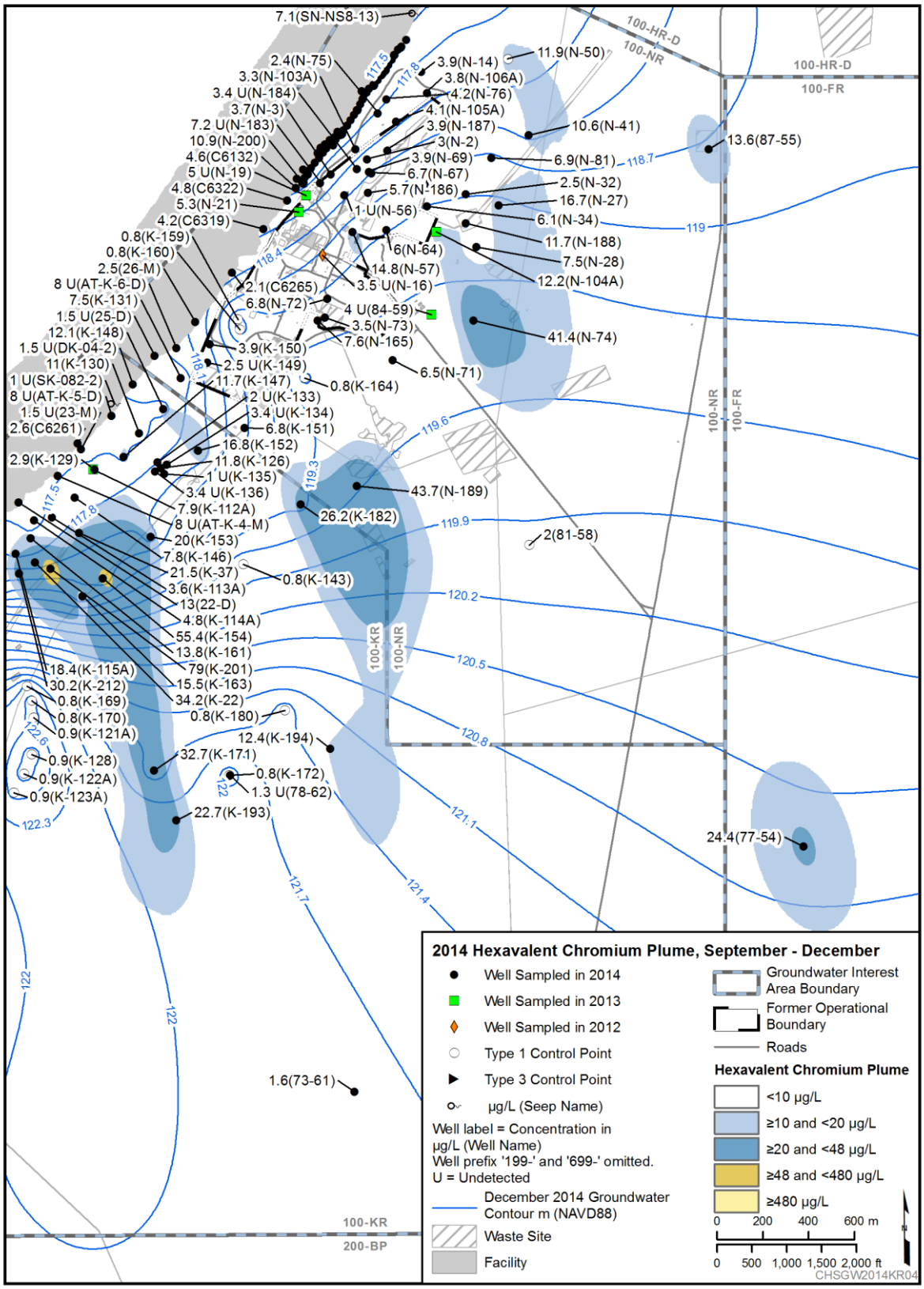

Figure 5-6. 100-KR Hexavalent Chromium Plume (Low River Stage), 116-K-2 Trench and 100-N Area, 2014

In addition to measurements collected from the near-river environment at aquifer tubes, river shore seeps at 100-KR Area were also sampled in 2014. The seeps are discrete areas of groundwater discharge to the ground surface near the river shore that appear during the low river stage and are most apparent during the falling limb of the river stage cycle. Seeps represent groundwater leaving the aquifer in areas where the groundwater elevation remains higher than the river elevation for some period of time. At the 100-KR Area, three seeps were sampled during 2014, all during September and October. The seep measurements provide useful information regarding near-shore surface water conditions, however, they do not technically represent groundwater. For information purposes, the 2014 seep sample results of hexavalent chromium measurements are posted on the hexavalent chromium plume maps for both low and high river stages in this report.

The Columbia River is a discharge boundary for groundwater beneath the 100-KR Area. When river stage is low (generally during the period from September through March [Figure 5-7]), groundwater flows readily toward the river and discharges into the river through areas of interaction in the hyporheic zone where the aquifer meets the surface water. The low river-stage period has been selected for collection of water samples from the aquifer tubes placed into the near-river environment at 100-KR. At this time, the chromium plume is most likely to be continuous between the inland aquifer and aquifer tube locations where hexavalent chromium is detected. During 2014, this condition occurred only at two locations. The inferred distribution of hexavalent chromium at 100-KR during the low river-stage period is shown in Figure 5-5 and 5-6.

Hexavalent chromium concentrations greater than 10 µg/L are observed in isolated wells east and northeast of 100-K Area: 699-87-55, 699-77-54 (Figure 5-6) and two wells farther east in the 100-FR groundwater interest area (Figure ES-7 in the Executive Summary). The origin of this contamination is unknown, but it may be related to historical sources in 100-K or 100-D Area.

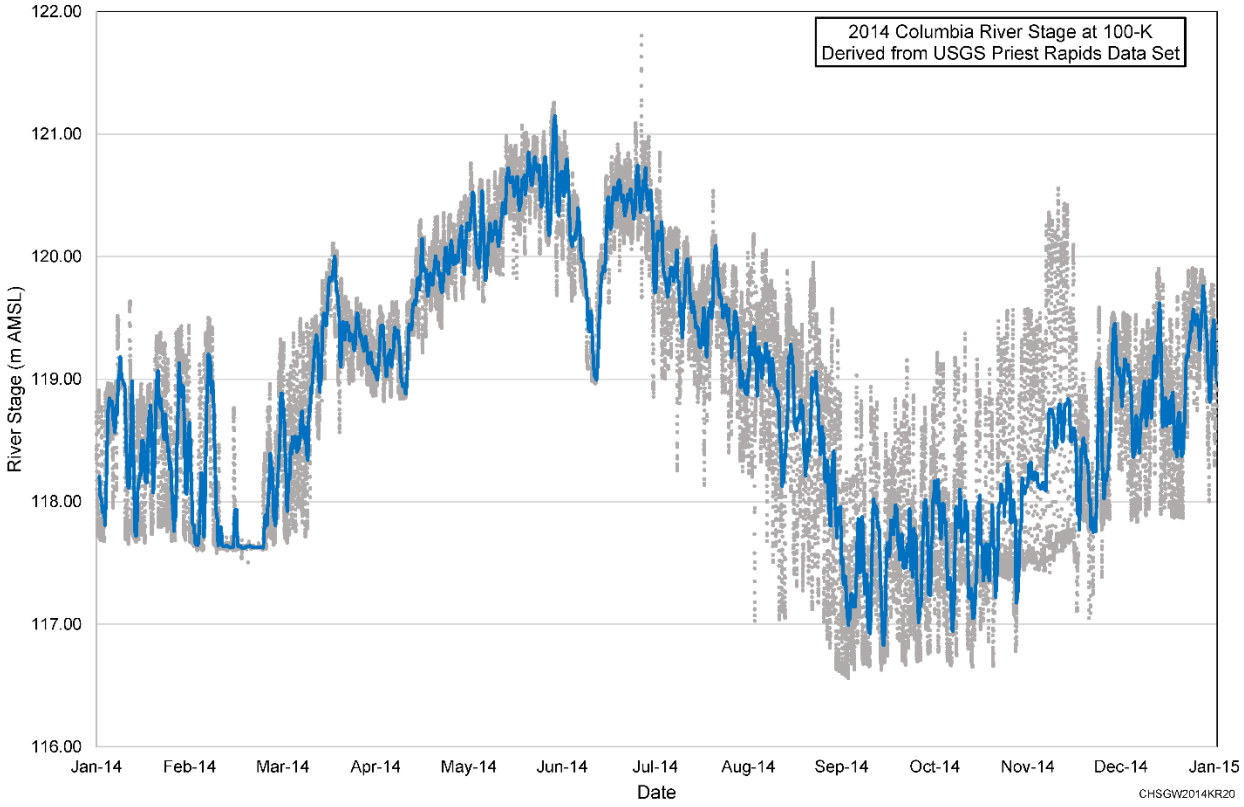

Figure 5-7. Columbia River Stage at 100-K During 2014

5.3.1 116-K-2 Trench Associated Plume

The current hexavalent chromium groundwater plume associated with the 116-K-2 Trench occurs in multiple, isolated plume segments at the 10 µg/L contour. This plume, which was initially inferred in the mid-1990s (see historical monitoring reports) as being continuous over the length of the 116-K-2 Trench, has been dissected by operation of the P&T systems. The northeastern portion of the 116-K-2 Trench plume extends northeast into the 100-NR-2 OU. Well 199-N-189, constructed in 2011, exhibited hexavalent chromium at 45 µg/L, similar to the range of 5 to 45 µg/L observed in Well 199-K-182, a 100-KX system extraction well. Well 199-N-74, which is located approximately 2 km (1.2 mi) from the end of the trench and farther north than Well 199-N-189, exhibited a hexavalent chromium concentration of about 45 µg/L in 2014. Hexavalent chromium concentrations near the river have been generally decreasing (Figures 5-8 and 5-9). Hexavalent chromium continues to be detected in wells further north within the footprint of 100-NR-2 OU. This includes a detection of 50.6 µg/L in a filtered aliquot collected in June 2014 in Well 199-N-41, located adjacent to the 116-N-3 Trench. This is the highest historical chromium concentration observed at this location. This single measurement expressed a substantial variation in the inferred hexavalent chromium plume distribution in the 100-N Area during the high river stage period (see Figure 5-6). The actual extent of the hexavalent chromium plume associated with Well 199-N-41 is highly uncertain due to the sparse quantity and frequency of measurements in nearby locations. The concentration at Well 199-N-41 was measured at 10.6 µg/L in the filtered aliquot in the September 2014 sample, which was more consistent with historical measurements.

A central plume segment, exhibiting concentrations greater than 10 µg/L extends from the vicinity of the 116-K-2 Trench inland to the vicinity of Well 199-K-193. Operation of injection wells of the KR4 and KX P&T systems has further dissected the hexavalent chromium plume in the central portion of the trench.

The hexavalent chromium plume associated with the proximal, or head end (southwest end) of the 116-K-2 Trench was previously inferred to be continuous with chromium originating at the 183-KE Head House area. The apparent source(s) of hexavalent chromium in groundwater in the vicinity of the 116-K-1 Crib include comingling of chromium from the crib and trench and likely chromium originating at the 183-KE Head House area. Concentrations of hexavalent chromium near the river have been generally decreasing in active extraction wells (Figure 5-8 and 5-9). The observation of a variable concentration of hexavalent chromium in Well 199-K-148 is consistent with active capture of chromium from upgradient (in the vicinity of Well 199-K-152). Hydraulic containment of the 100-KR plumes is illustrated in Figure 3-22 of DOE/RL-2015-05.

For 2014, as in 2013, the consistent groundwater flow vectors caused by the combination of forces related to recharge mounding from injection wells, and capture by extraction wells, were critically evaluated during plume distribution analysis. As illustrated in Figure 5-5, the hexavalent chromium plume in the vicinity of Well 199-K-111A is inferred to be continuous with groundwater to the east of that well location (i.e., in the vicinity of the 116-K-2 Trench and 118-K-1 Burial Ground). The inferred continuity of the 10 µg/L contour between the 183-KE Head House and 199-K-111A may be an artifact of sparse measurement data between these two vicinities. The dynamic conditions imparted on the aquifer by operation of the P&T systems are apparent as an east-to-west groundwater gradient in this area that segregates the hexavalent chromium plume into two distinct segments.

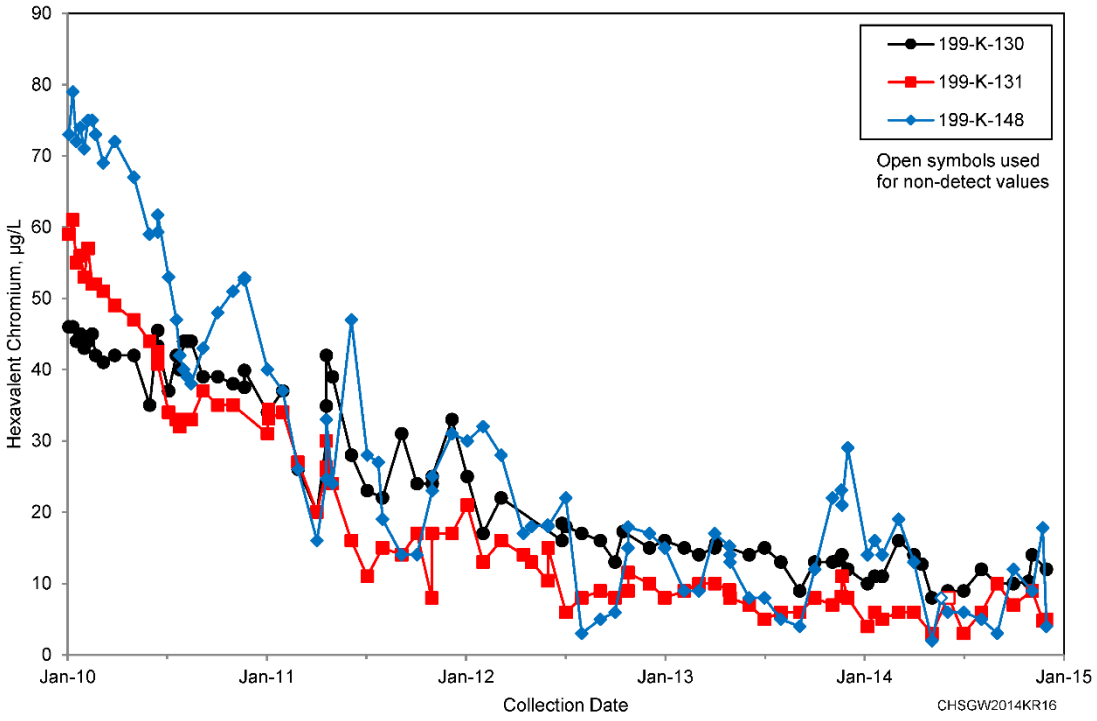

Figure 5-8. 100-KR Hexavalent Chromium Data for Wells 199-K-130, 199-K-131, and 199-K-148 (Near-River Extraction Wells in Northern Portion 100-KR)

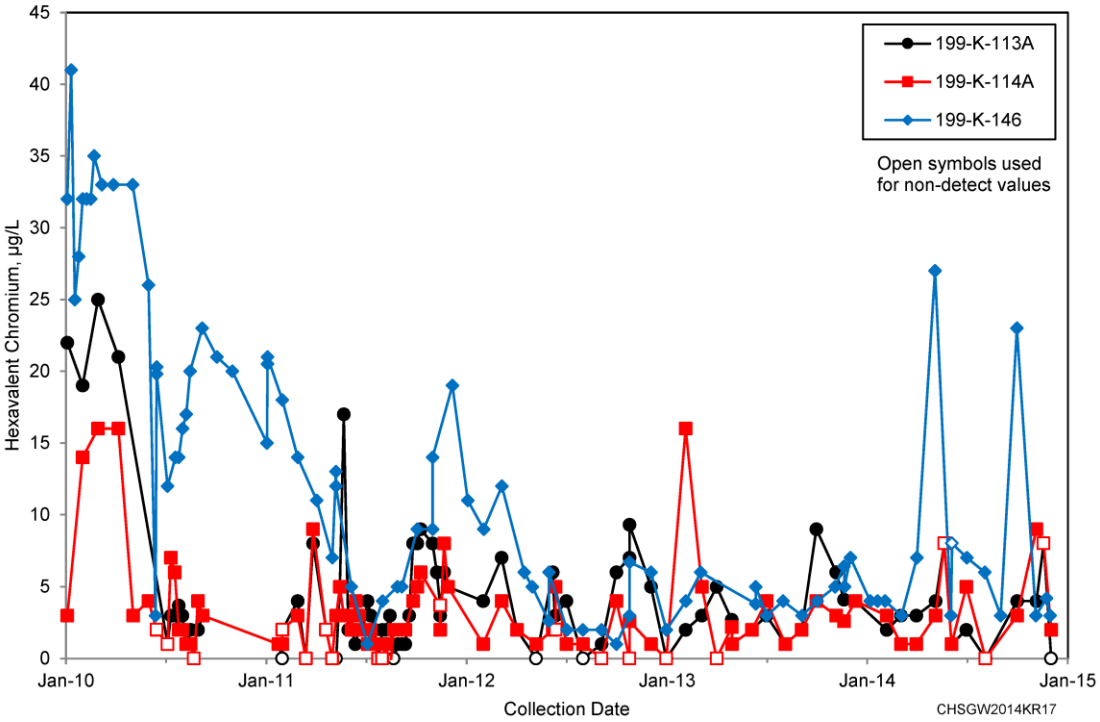

Figure 5-9. 100-KR Hexavalent Chromium Data for Wells 199-K-113A, 199-K-114A, and 199-K-146 (Near-River Extraction Wells in Northern Portion 100-KR)

5.3.2 K West Associated Plume

The K West hexavalent chromium plume is observed in a narrow band with relatively high concentrations starting near the head house and extending toward the river (Figure 5-5). The dimensions of this plume did not change substantially between 2011 and 2014. The highest hexavalent chromium concentrations in 100-KR in 2014 continued to be observed in wells upgradient from the KW Reactor building and extending to the 183-KW Head House vicinity.

With the decommissioning of Well 199-K-195, which previously exhibited the highest hexavalent chromium concentration of 3,340 µg/L (April 2011), in preparation for soil remedial activities, no wells remained in the vicinity of the KW Head House until construction of Well 199-K-205 in early 2014 as an additional extraction well for the 100-KW system. A maximum concentration of 3,280 µg/L was observed in January 2014 at this well. Elevated concentrations greater than 1,000 µg/L persisted until the well was brought online as an extraction well in September 2014. During extraction operations, Well 199-K-205 hexavalent chromium concentration has declined from 1,020 µg/L in September to about 200 µg/L in December 2014. The persistence of elevated hexavalent chromium concentration at this well, and the next downgradient well (199-K-173), indicates the likelihood of continuing contributions from secondary sources within the overlying vadose zone or periodically rewetted zone.

The next downgradient extraction well (199-K-173) continued to exhibit elevated, although decreasing, concentrations of hexavalent chromium during 2014. Hexavalent chromium, observed in that well at a high of 500 µg/L in late 2011, declined to about 30 µg/L at the end of 2014. The presence of injection Wells 199-K-175, 199-K-174, and 199-K-158 controls the upgradient edge of the plume. The plume does not extend inland past Well 199-K-175, which had concentrations below 10 µg/L when the well was sampled before conversion to an injection well for the KW P&T system.

At 2014 low river stage, Aquifer Tube AT-K-1-D exhibited less than 8.0 µg/L of hexavalent chromium; this is consistent with the 6.1 µg/L detected in 2013 and maintains the substantial decrease from the 32.7 µg/L observed at that location in 2012. The 100-KW system extraction Well 199-K-196 operated for all of 2014; this supplemented extraction by Wells 199-K-132 and 199-K-138 (Figure 5-10). This operation appears to be capturing contaminated groundwater from the KW plume inland of the river shore. Well 199-K-196 exhibited an increase in hexavalent chromium concentration to 32 µg/L shortly after being placed in service as an extraction well in 2013, and exhibited decreasing concentration to less than 20 µg/L by the end of 2014. Representative concentration trends for wells near the river and upgradient of the KW Reactor are shown in Figures 5-10 and 5-11. Of particular interest with respect to hexavalent chromium, Seep SK-063-1, located in the vicinity of the 100-KW chromium plume, exhibited a filtered total chromium concentration of 4.3 µg/ L in October 2014; this is a substantial decrease from the 24.6 µg/L in a sample collected in September 2013. This seep concentration is consistent with the less than 8 µg/L reported for nearby aquifer tube AT-K-1-D in September 2014. Continued operation of extraction Well 199-K-196 is anticipated to intercept the leading edge of the hexavalent chromium plume; monitoring activities at Aquifer Tube AT-K-1-D and Seep SK-063-1 will continue to support performance evaluation of the KW extraction system.

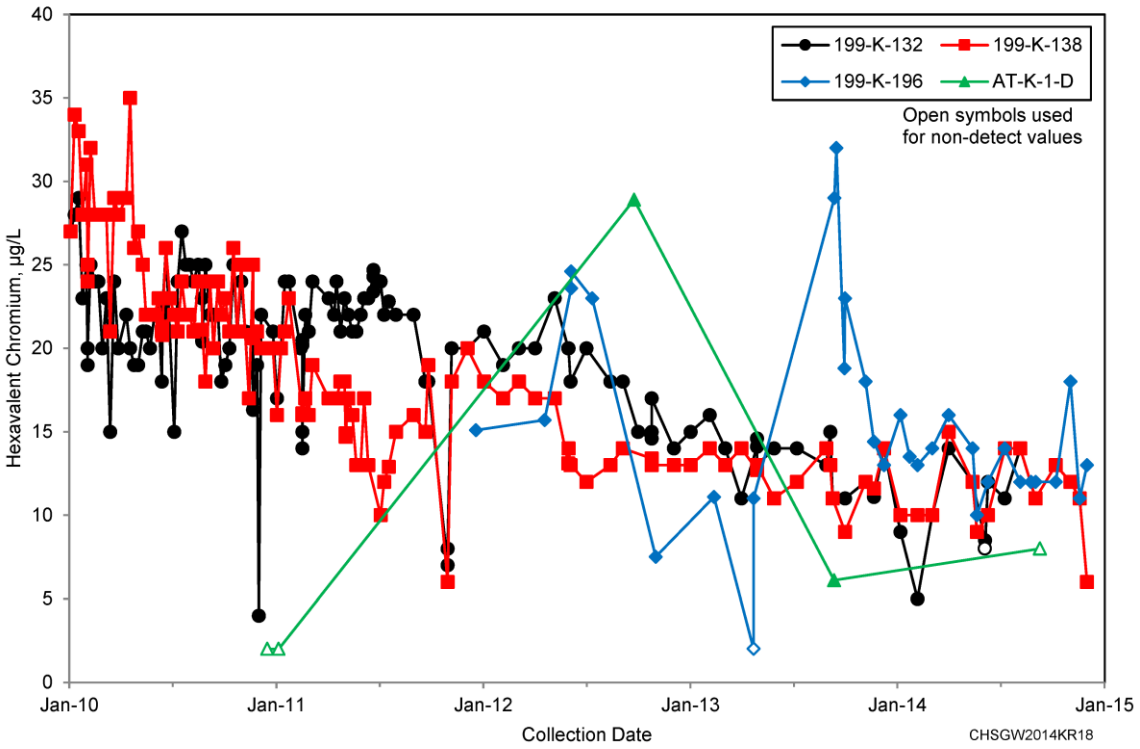

Figure 5-10. 100-KR Hexavalent Chromium Data for Wells 199-K-132, 199-K-138, 199-K-196, and Aquifer Tube AT-K-1-D, Located Downgradient of KW Reactor

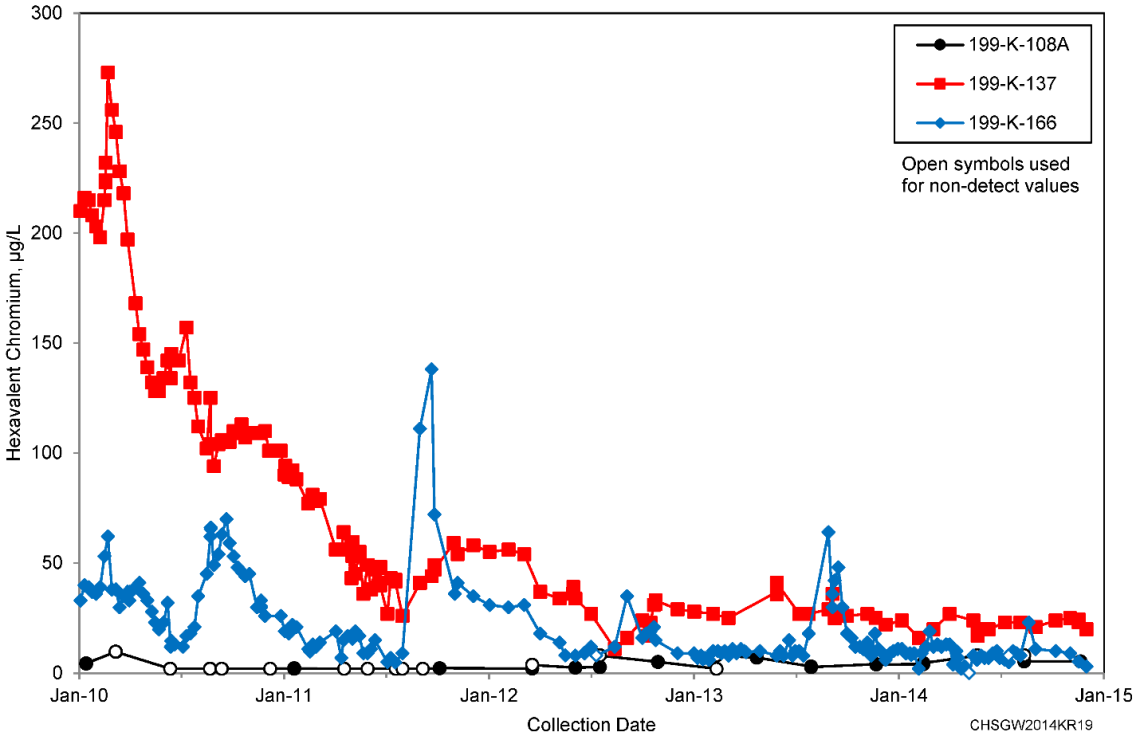

Figure 5-11. 100-KR Hexavalent Chromium Data for Wells 199-K-108A, 199-K-137, and 199-K-166, Located Just Upgradient of KW Reactor

5.3.3 K East Associated Plume

The K East plume is a relatively high concentration plume that extends from the vicinity of the 183-KE Head House in a northwest direction to the Columbia River (Figure 5-5). The apparent source is in the vicinity of the 183-KE Head House chemical storage tank farm, similar to the condition observed at KW. The existing monitoring well network does not clearly define the dimensions of the K East hexavalent chromium plume, but the plume definition has improved from previous years. Upgradient (inland) of the 183 KE Head House, Well 199-K-187 exhibited hexavalent chromium less than 8 µg/L in 2014. This location has consistently exhibited low hexavalent chromium concentration and appears to define the inland extent of elevated concentrations for this plume segment.

The plume extends from the 183-KE Head House (near Wells 199-K-36 and 199-K-188) toward the river. As described above for the plume related to the 116-K-2 Trench, evaluation of the dynamic groundwater gradients influenced by extraction and injection well operations produced an inferred hexavalent chromium plume distribution that differs from previous years. Chromium concentrations in Wells 199-K-36 (located at the former KE Head House) and 199-K-111A (located east of the KE Reactor and just west of the 118-K-1 Burial Ground) increased between 2010 and 2013, and declined in 2014. Examination of the concentration time series for co-contaminants, however, suggests that the chromium at these two wells likely originated from separate source areas. In Well 199-K-36 (at the head house), chromium and sulfate have increased in a parallel manner, while tritium has remained very low. At Well 199-K-111A (east of KE Reactor), chromium and tritium have increased in a parallel manner, while sulfate has remained relatively low. These relationships suggest that the chromium at Well 199-K-111A is likely related to a plume segment historically related to the 116-K-2 Trench moving westward coincidentally with tritium potentially originating from the burial ground. The westward flow at this location is apparently induced by the persistent recharge mound associated with the KR4 and KX injection wells located to the east. Elevated tritium was present in deep vadose zone soil beneath the 118-K-1 Burial Ground. A new monitoring well (199-K-207) was installed during 2014 to monitor conditions beneath the 118-K-1 Burial Ground. A sample collected during drilling exhibited 414,000 pCi/L tritium. This condition, located upgradient of Well 199-K-111A, is consistent with the tritium behavior in that well. The hexavalent chromium observed in Well 199-K-111A probably originated from historical discharges of reactor cooling water to the 116-K-2 Trench.

The increasing chromium observed at Well 199-K-36 (to a maximum concentration of 316 µg/L in 2014) is most likely related to continuing contribution from secondary sources in the vadose zone in the vicinity of the former head house chemical storage tank farm, migrating to groundwater coincidentally with sulfate residuals from historical release of other water treatment chemicals (e.g., alum or sulfuric acid) managed in the same tank farm area. Sulfate has exhibited a similar behavior in concentration time series to hexavalent chromium at Well 199-K-36. These separate source conditions are consistent with the current inferred plume distribution based on apparent groundwater flow gradients.

The K East plume is interpreted to reach the Columbia River at aquifer tube C6246. The hexavalent chromium concentration in this tube increased to 12 µg/L in 2014, having been below the 10 µg/L aquatic standard in 2012 and 2013.

5.4 Hexavalent Chromium – High River Stage

The observed stage in the Hanford Reach of the Columbia River varies daily with controlled release of water from the upstream Priest Rapids Dam and seasonally in response to annual snowmelt in the mountains of the drainage upstream. High river stage in the Hanford Reach of the Columbia River typically occurs in mid-summer at the peak of the annual freshet. A hydrograph of river stage at 100-K Area is shown in Figure 5-7. The high water stage was observed to begin in early March, and three

distinct peak responses were observed in 2014: one peak was observed in late March at about 120.1 m (394 ft) amsl, and two higher peaks in early June and early July at about 121.2 m (398 ft) amsl. The peak river stage elevations at 100-K Area in 2014 were similar in timing and magnitude to the corresponding peak stage elevations observed in 2013. The high river-stage period continued through the decline of the peak stage through August 2014. The low river-stage period was identified to have started in late August 2014.

Based on concentrations of hexavalent chromium in groundwater samples collected during the 2014 high river-stage period, the distribution of plumes within 100-KR at high river stage (Figures 5-12 and 5-13) are not dramatically different from those observed during the low river period. During the high river stage, river water may intrude into the aquifer, causing displacement and/or dilution of the aquifer water in the near-shore environment. During 2014, this bank storage condition may have occurred, based on evaluation of groundwater elevation maps. Due to increased pumping rates at groundwater extraction wells, particularly those riverward of the distal portion of the 116-K-2 Trench, groundwater gradient reversal near the river appears to have occurred at some locations. In particular, Wells 199-K-112A and 199-K-129 exhibited specific conductance measurements consistently below 200 µS/cm. This specific conductance is consistent with influence of mixing of groundwater with river water. The Columbia River water typically exhibits specific conductance of 130 to 140 µS/cm. A classified post map of measured groundwater specific conductance is shown in Figure 5-14. The measured hexavalent chromium concentrations in aquifer tubes collected during the low water period were, therefore, applied to those locations to prepare the high river stage plume maps. This was determined to be the most representative interpretation of the conditions observed during 2014. Inspection of the groundwater elevation contours for 2014 indicate that the P&T system imposed hydraulic capture of groundwater along the affected shoreline over most of the year (Figure 3-22 of DOE/RL-2015-05).

Some inland wells (e.g., wells more than 200 m [660 ft] away from the river shore) exhibit transient hexavalent chromium concentration effects during periods of seasonal high groundwater elevation. An example of this effect is shown at Well 199-K-189, located in the vicinity of the KE Reactor (Figure 5-15). This well has consistently exhibited seasonal concentration transients that appear to be directly proportional to changes in groundwater elevation (i.e., as groundwater elevation rises, hexavalent chromium concentration rises). The direct correlation indicates that this well may be located close to a secondary source within either the vadose zone or periodically rewetted zone.

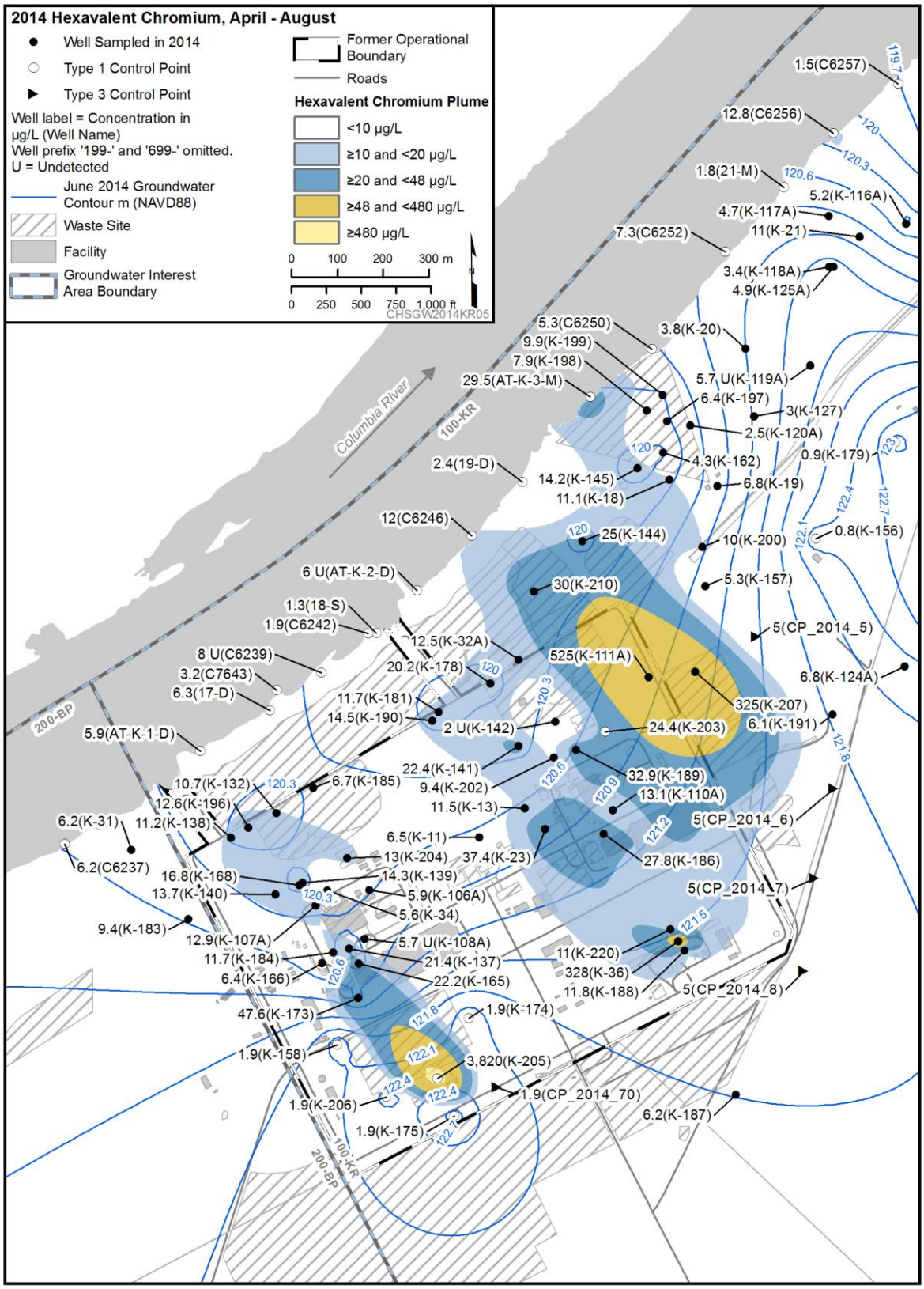

Figure 5-12. 100-KR Hexavalent Chromium Plume (High River Stage), KE and KW Vicinity, 2014

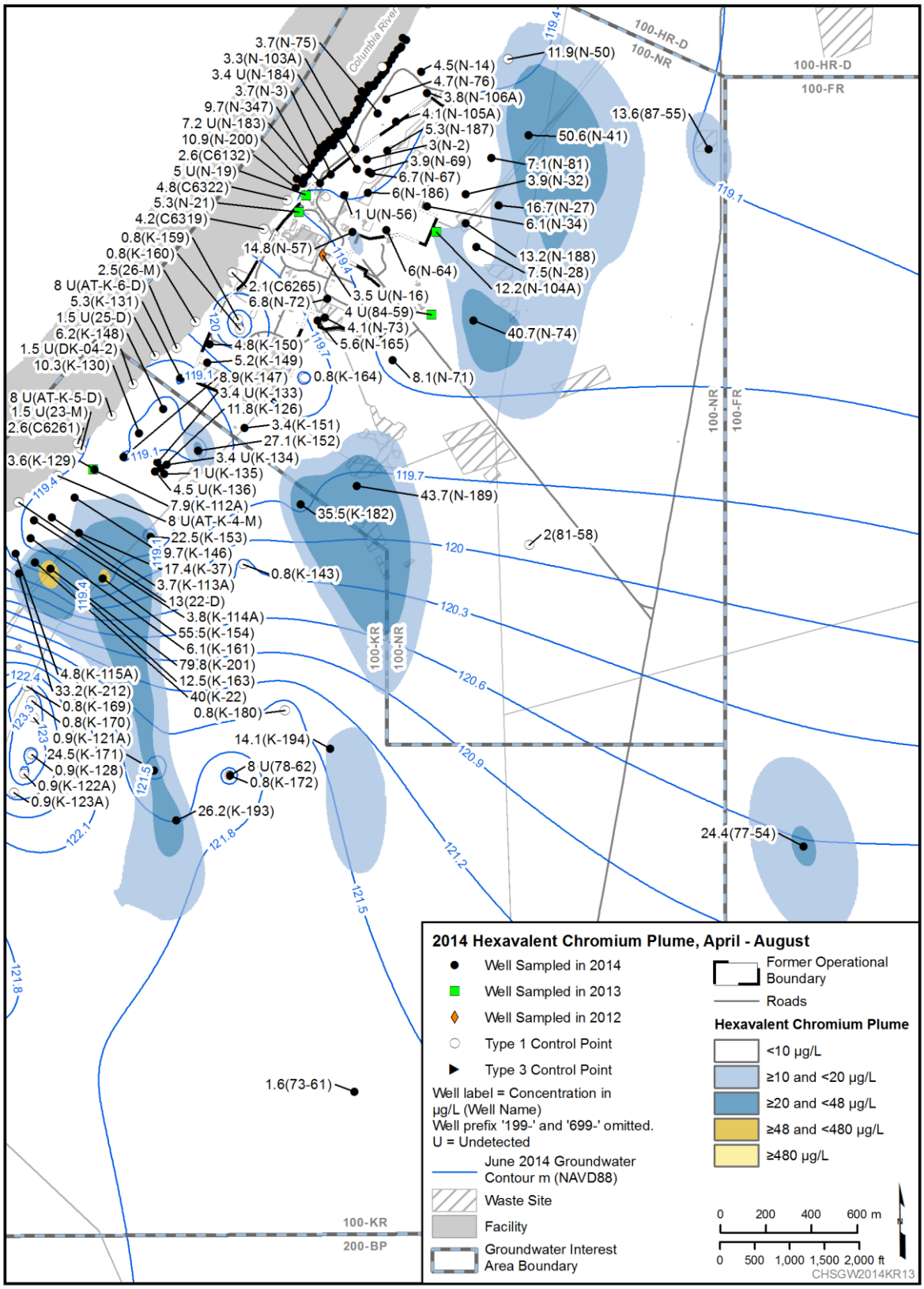

Figure 5-13. 100-KR Hexavalent Chromium Plume (High River Stage), 116-K-2 Trench and 100-N Area, 2014

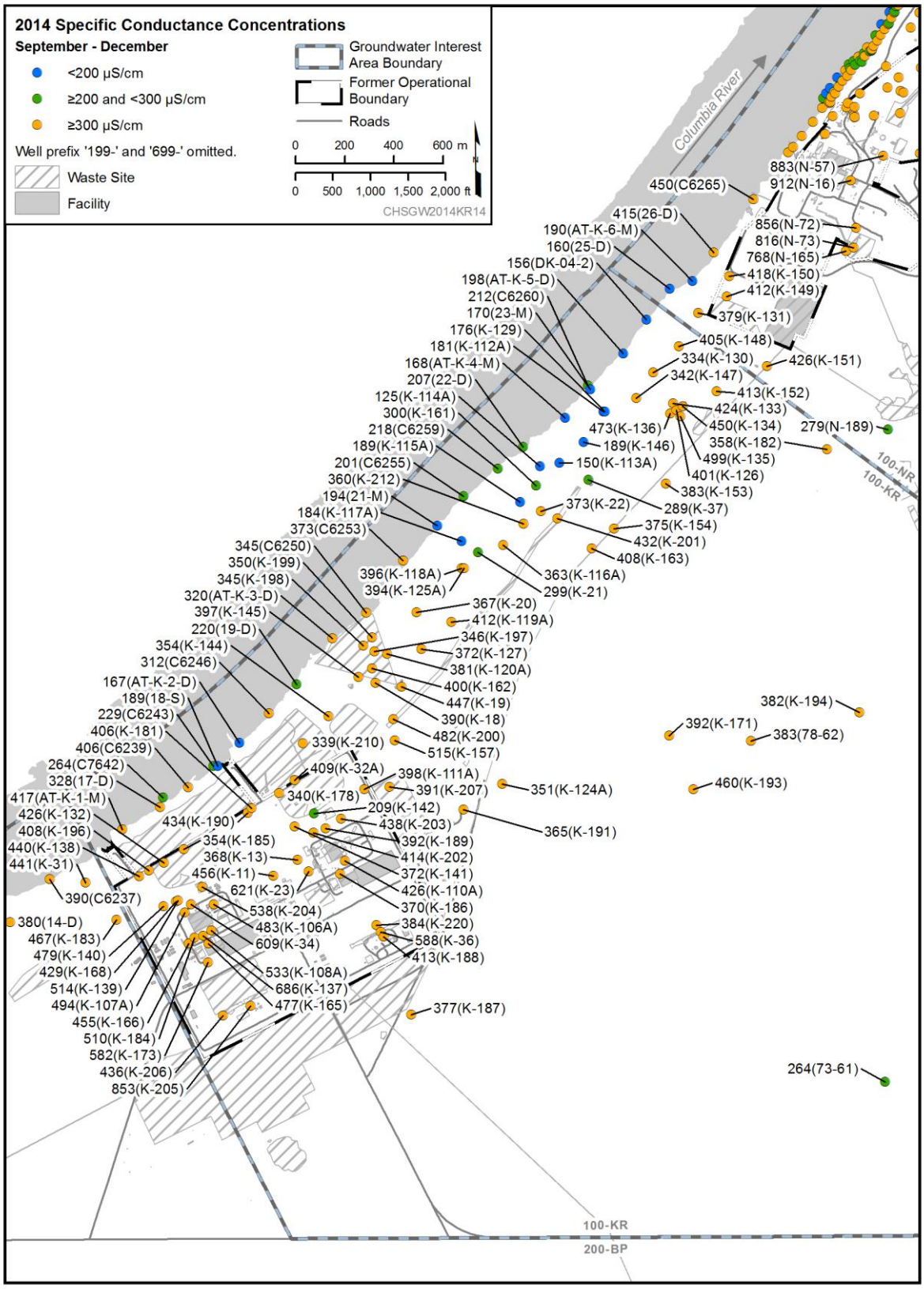

Figure 5-14. 100-KR Specific Conductance, Low River Stage 2014

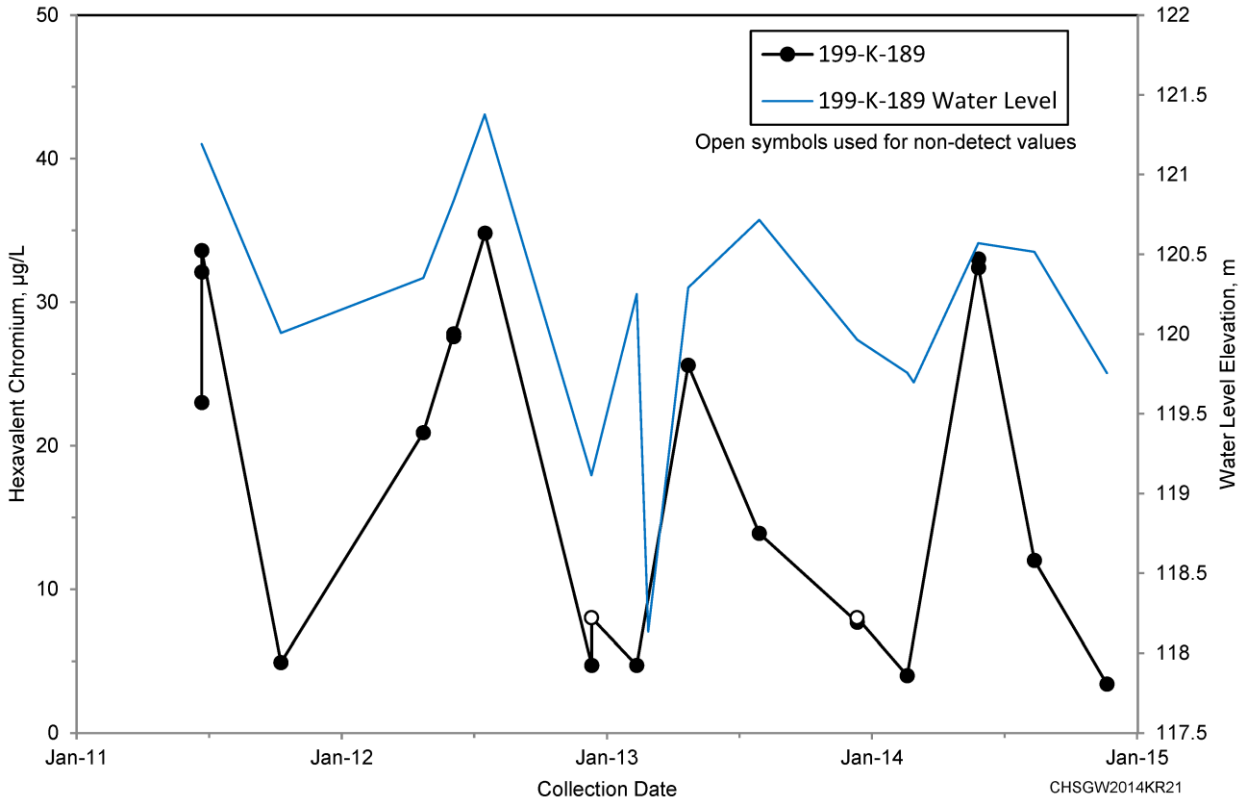

Figure 5-15. 100-KR Hexavalent Chromium Data for Well 199-K-189, Located Downgradient of KE Reactor, Indicating Correlation to Transient Water Level

5.5 Tritium

Tritium is a highly mobile contaminant in 100-KR groundwater and is present at levels above the 20,000 pCi/L DWS equivalent concentration. The major historical sources of tritium contamination included the following:

- Releases of reactor gas dryer condensate to the 116-KE-1 and 116-KW-1 Cribs (tritium activity concentrations up to 1×10^{10} pCi/L in the condensate, per HW-76258, *Reactor Gas Drier Condensate Waste – Decontamination Studies*)
- Release of fuel storage basin water to the 116-KE-3 and 116-KW-2 Cribs, and to UPR-100-K-1 (tritium activity concentrations up to 6×10^{9} pCi/L in the basin water, per WHC-EP-0877, *K Basin Corrosion Program Report*)
- Contaminated solid waste disposed at the 118-K-1 Burial Ground (tritium activity concentrations up to 13,400 pCi/g in deep vadose zone soil remaining after surface remediation, per CVP-2013-00002, Rev. 1)

Another source of tritium was the release of contaminated reactor cooling water to the retention basins, the 116-K-1 Crib, and the 116-K-2 Trench. The tritium distribution in groundwater in 2014 is shown in Figure 5-16.

As part of the active remediation of hexavalent chromium, extraction wells are also capturing tritium in this area. Because tritium is present primarily as tritiated water, it passes through the treatment system unaffected. Currently, the tritium-contaminated water within the aquifer is recirculated between affected

extraction wells and inland injection wells. Because of extraction and recirculation, tritium is now in groundwater at the active injection wells at 100-KR. Based on the design of the P&T system, much of this water will be recaptured by the downgradient extraction wells and the tritium will be recirculated and continue to decay. The plume is not presently reaching the river above the DWS, based on data from aquifer tubes. Tritium was detected in effluent water from the KW, KX, and KR4 P&T systems. The average effluent concentration of the KR4 system for 2014 was 6,835 pCi/L, which is below the DWS. Tritium concentration in the effluent from both KX and KW systems was less than 2,000 pCi/L during 2014, consistent with conditions observed in 2013.

The highest measured tritium value in groundwater during 2014 (414,000 pCi/L) was in a characterization sample from the new Well 199-K-207, located within the footprint of the former 118-K-1 Burial Ground. Tritium at this location is likely related to historical disposal of contaminated reactor hardware to the burial ground. Six monitoring wells at 100-K exhibited tritium concentrations exceeding 20,000 pCi/L in 2014 (199-K-18, 199-K-111A, 199-K-145, and 199-K-202 and the new Wells 199-K-207 and 199-K-208).

A portion of the tritium plume at K East appears to have originated at the 116-KE-1 Crib, with contribution from waste at the 118-K-1 Burial Ground (Figure 5-16). Concentrations in 2014 in Well 199-K-18 declined slightly in 2014, with one measurement below 20,000 pCi/L. Well 199-K-111A exhibited a declining trend in tritium concentration during 2014 after 2 years of rising concentration (Figure 5-17). This is inferred to result from westward migration of tritium-contaminated groundwater from the vicinity of the 118-K-1 Burial Ground. Tritium concentration in this well location is expected to increase with continued westward migration of contaminated groundwater. The new Well 199-K-207 was installed upgradient of Well 199-K-111A to provide information on conditions beneath the burial ground; this well exhibited 414,000 pCi/L tritium in a grab sample near the water table during drilling. In addition to the elevated tritium observed in Well 199-K-207, new extraction Well 199-K-208, located approximately 220 m (730 ft) northwest of Well 199-K-207, exhibited 271,000 pCi/L tritium in a shallow grab sample collected during drilling. Concentrations declined with depth in Wells 199-K-207 and 199-K-208. Tritium in Well 199-K-157 remained below 5,000 pCi/L during 2014 (Figure 5-16). This pattern is consistent with migration of contaminated groundwater from historical release points along inferred flow paths to locations where it is intercepted by extraction wells. The known historical release points (118-K-1 Burial Ground, 116-KE-1 Crib) may also be continuing secondary sources in the vadose zone and/or periodically-rewetted zone.

Tritium concentrations in K West in 2013 were consistently below the DWS. However, concentrations as high as 430,000 pCi/L were measured in Well 199-K-106A as recently as 2009 (with a historical maximum observed concentration of 2,240,000 pCi/L in 2005). Well 199-K-106A exhibited tritium at a maximum concentration of 2,370 pCi/L during 2014. It is unlikely that the plume has disappeared because the half-life of tritium is 12.3 years, but the plume has likely migrated downgradient to a location without monitoring wells. New Well 199-K-204 is located in this area of uncertainty to provide information on carbon-14 and tritium.

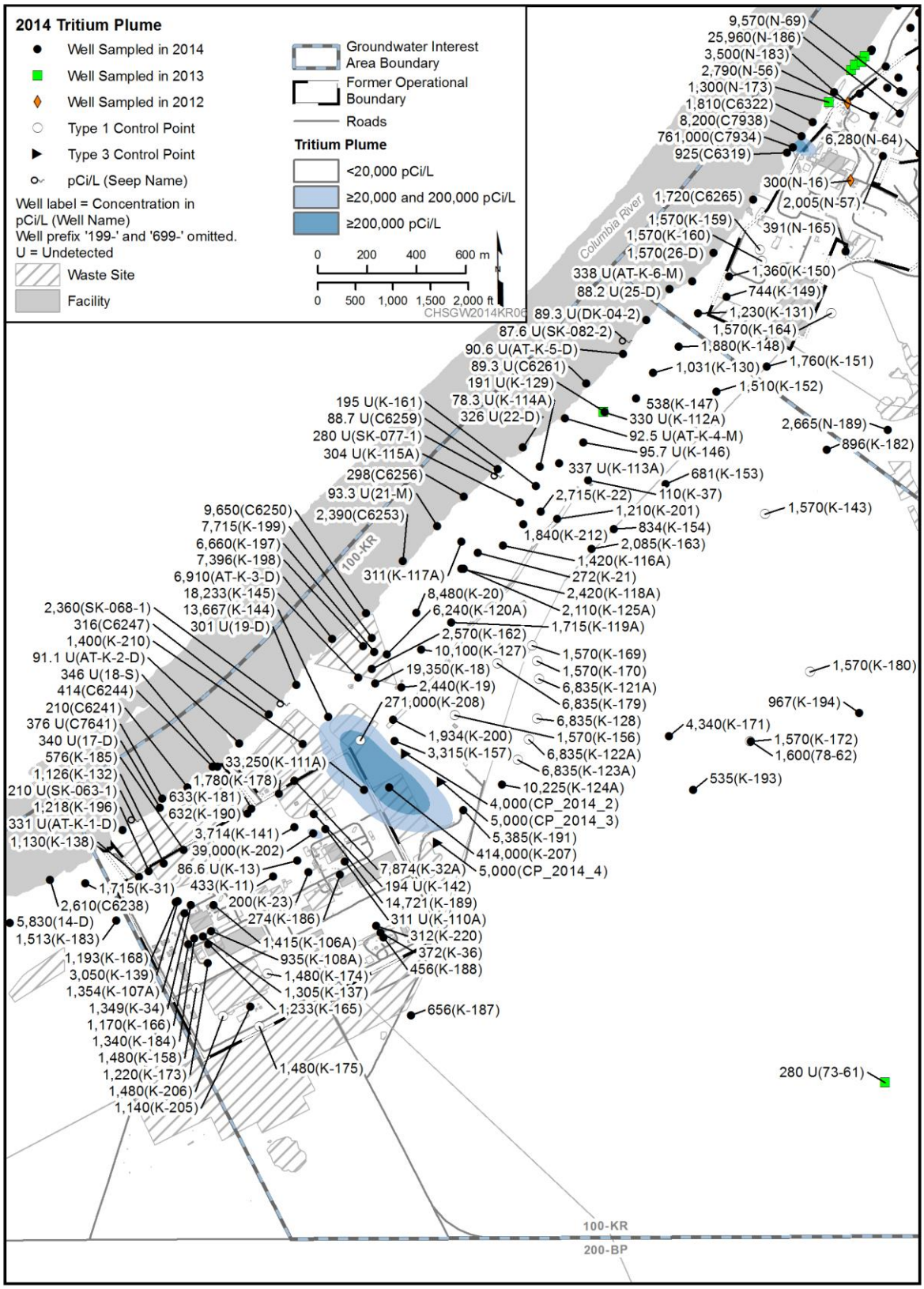

Figure 5-16. 100-KR Tritium Plume, 2014

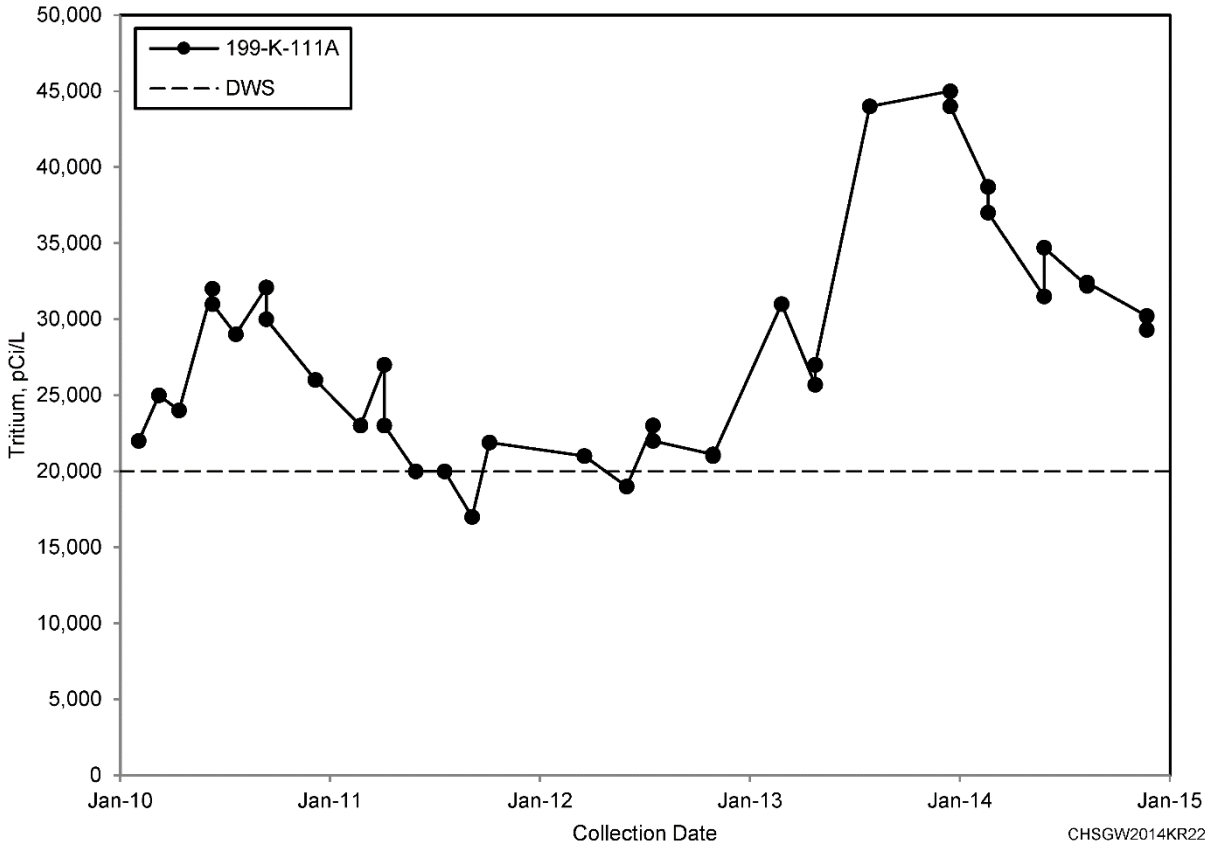

Figure 5-17. 100-KR Tritium Data for Well 199-K-111A, Located Northeast of KE Reactor

5.6 Nitrate

Nitrate concentrations continued to exceed 45 mg/L in several 100-KR wells in 2014. The nitrate observed in groundwater at 100-KR originated primarily from oxidation of high concentrations of ammonia in reactor gas dryer condensate (up to 36,000 mg/L) that was discharged to the 116-KE-1 and 116-KW-1 Cribs. Additional nitrate contributions to groundwater may have come from sanitary waste drain fields at various locations within the 100-KR Area. Nitrate distribution in groundwater in 2014 is shown in Figure 5-18. The size of the plume area exceeding the DWS decreased between 2011 and 2012, but remained fairly stable in 2013 (Figure 5-3).

In the K East region, only Well 199-K-23 exhibited a nitrate concentration above 45 mg/L in 2014, with a maximum observed concentration of 66.8 mg/L (Figure 5-19).

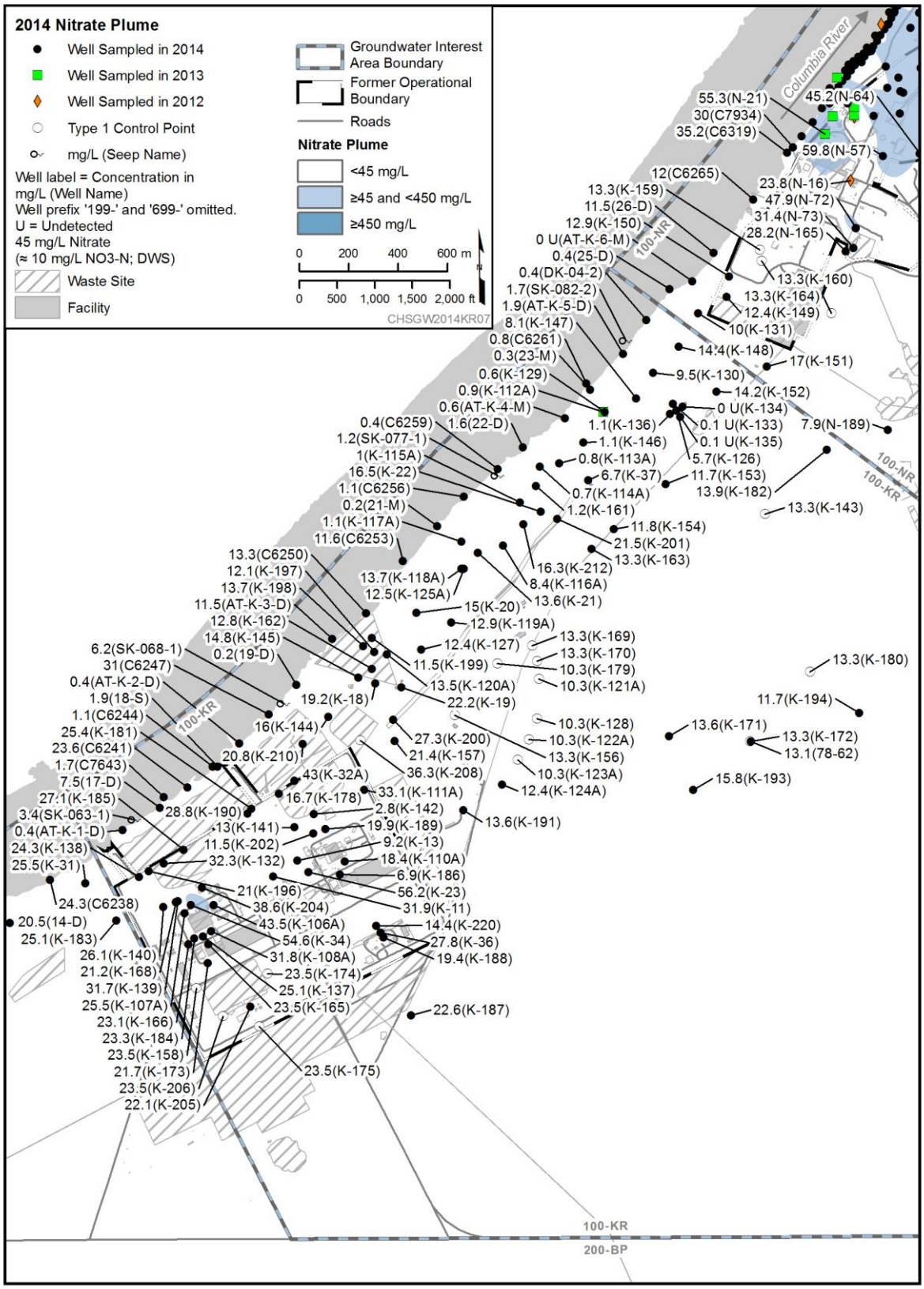

Figure 5-18. 100-KR Nitrate Plume, 2014

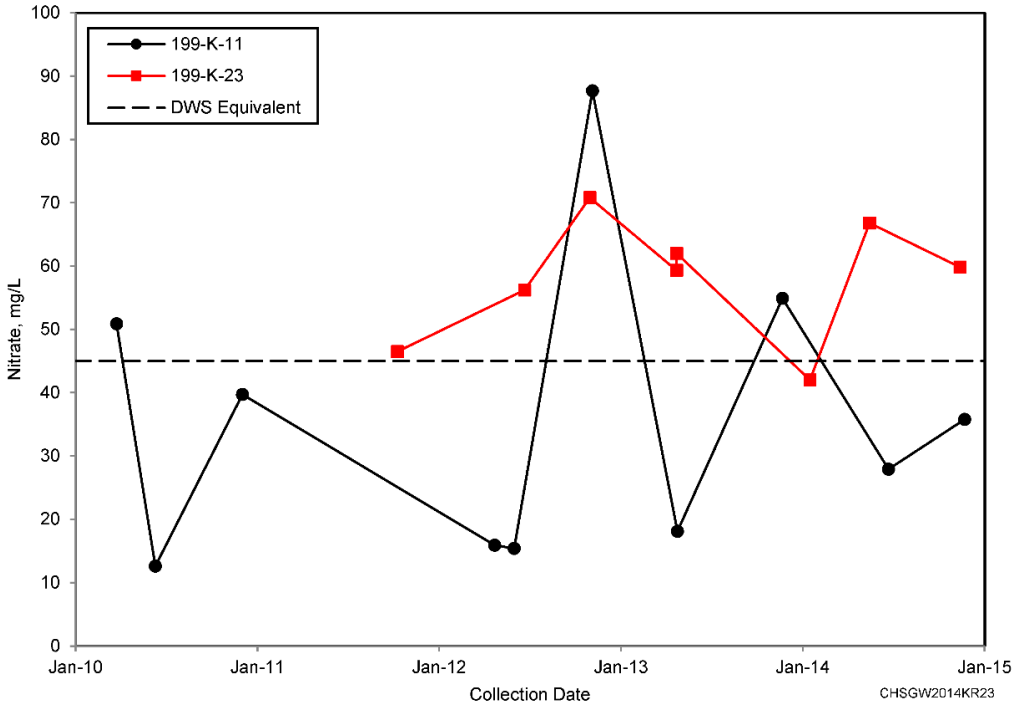

Figure 5-19. 100-KR Nitrate Data for Wells 199-K-111 and 199-K-23, Located West of KE Reactor

Two K West wells had nitrate levels above 45 mg/L in 2014 (199-K-34 and 199-K-106A) (Figure 5-20), although the nitrate concentration in Well 199-K-106A declined to about 39 mg/L by the end of the year. These are the two nearest wells to the 116-KW-1 Gas Condensate Crib, a known source of nitrate contamination. Two aquifer tubes downgradient from K West have historically exhibited nitrate concentrations above 45 mg/L (C6241 and 17-D), but have been below 45 mg/L since 2013 and 2011, respectively. Of particular interest with respect to nitrate, Seep SK-063-1, located in the vicinity of the 100-KW nitrate plume, exhibited a nitrate concentration of 3.4 mg/L in a sample collected on October 21, 2014. This is consistent with the nitrate concentrations measured in nearby Aquifer Tubes AT-K-1-D and 17-D (0.4 and 7.5 mg/L, respectively). This condition suggests that the KW P&T system is providing hydraulic capture of the plumes in the KW Reactor vicinity. It is notable that the concentration of nitrate in the treated effluent from 100-KW P&T system was 23 mg/L during 2014, consistent with 23 mg/L measured in 2013. This also indicates that the system is capturing the nitrate plume. Nitrate concentration in the effluent of 100-KR and 100-KX P&T systems was 10.3 and 13.3 mg/L, respectively.

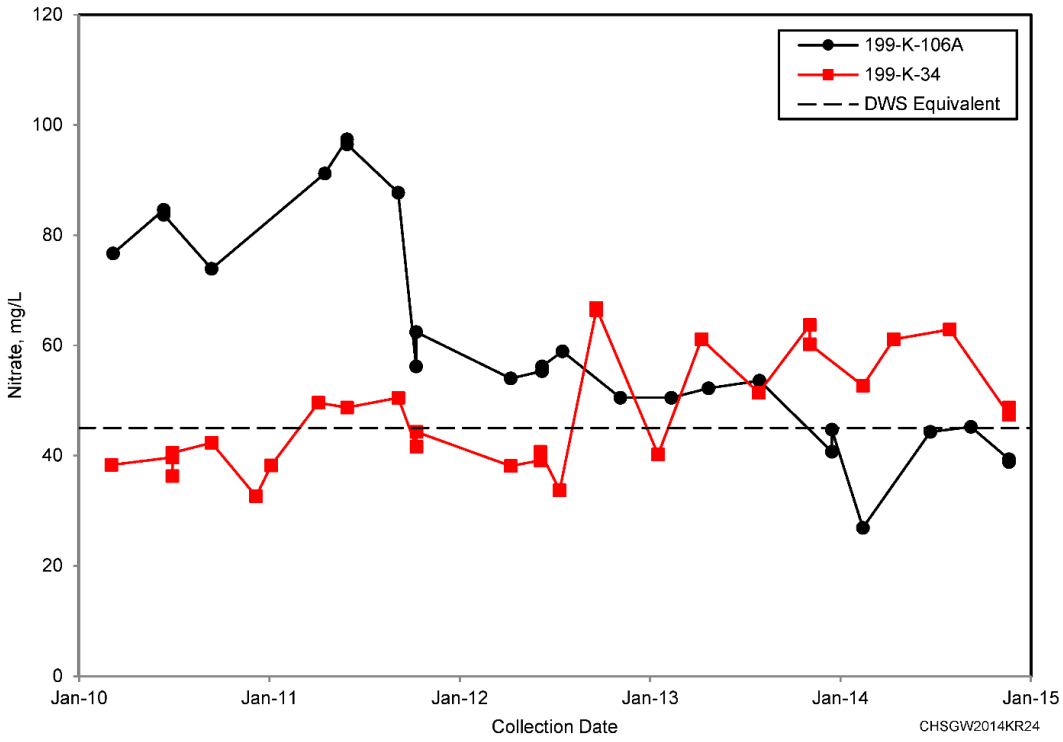

Figure 5-20. 100-KR Nitrate Data for Wells 199-K-106A and 199-K-34, Located Near KW Reactor

5.7 Strontium-90

Strontium-90 is a fission product generated within the reactor fuel during nuclear fission. Strontium-90 was historically released during fuel failure events and resulted in contamination of reactor cooling water. Contaminated cooling water, along with fragments of irradiated fuel, could be released to the 116-K-2 Trench under off-normal conditions as well as being released to the reactor fuel storage basins during discharge of irradiated fuel from the reactors. Cooling water contaminated by fuel rod failures was held in the 107-KE or 107-KW Retention Basins and subsequently discharged to the 116-K-2 Trench. Fission products, including strontium-90, contaminated the discharged water. The highest strontium-90 concentrations in groundwater are associated with historical releases from the fuel storage basins and their associated drainage systems. The fuel storage basins also contained cooling water contaminated with strontium-90. Releases from the fuel storage basins and discharges to the 116-K-2 Trench are the apparent sources of the strontium-90 contamination in 100-KR groundwater. Discharges to the 116-K-2 Trench resulted in strontium-90 distributed in groundwater at several locations along the length of the trench. Strontium-90 has also been released to groundwater via discharges to the 116-KW-2 and 116-KE-3 Fuel Storage Basin Cribs and reverse wells, or by direct leakage from the basins themselves (e.g., UPR-100-K-1 at the 105-KE Fuel Storage Basin). In 2013, DOE installed monitoring Well 199-K-202 downgradient of the KE Reactor to help delineate the strontium-90 plume in that area. Samples from this well exhibited no detectable strontium-90 during 2013 and 2014, indicating that this well location provides a bounding measurement for the high strontium-90 concentration plume historically defined by decommissioned Well 199-K-109A.

Strontium-90 contamination in 100-KR groundwater is found in four localized plumes at concentrations exceeding the DWS of 8 pCi/L (Figure 5-21). These plume areas are relatively small and approach, but do not reach, the Columbia River, except at the distal end (northeast end) of the 116-K-2 Trench, where aquifer tube 22-M exhibited a strontium-90 concentration of 7.2 pCi/L in 2014, slightly lower than the

8.8 pCi/L observed in 2013. This condition appears to represent downgradient migration of strontium-90 from the vicinity of the trench, where inland Wells 199-K-114A and 199-K-161 have both exhibited decreasing strontium-90 concentrations since 2000. The maximum 2014 strontium-90 concentrations in those wells were 3.3 and 11.8 pCi/L, respectively.

The historical area of the strontium-90 plume above the DWS is subject to substantial uncertainty because the plumes have not historically been delimited on the downgradient or cross gradient directions from either of the fuel storage basin cribs. The 2014 plumes were also interpreted to be smaller than in previous years as concentrations at wells located near the release points declined. The strontium-90 plume areas for 2014 are similar to 2013.

Many of the wells monitoring the 116-K-2 Trench have detectable strontium-90, but most concentrations are below or near the DWS of 8 pCi/L. The highest concentrations near the trench in 2014 were at Well 199-K-200 (Figure 5-22), which was drilled through the former trench near the head end (southwest). Concentrations in this well remained fairly stable in 2014 at about 200 pCi/L. Concentrations in other wells in the 116-K-2 Trench region were consistently less than 30 pCi/L. Strontium-90 has migrated away from the 116-K-2 Trench downgradient toward the Columbia River in at least two locations; downgradient Wells 199-K-19, 199-K-21, 199-K-22, and 199-K-161 all exhibited at least one measurement of strontium-90 exceeding the DWS during 2014. Aquifer tube 22-M, located along the Columbia River shore downgradient of the distal end of 116-K-2 Trench, exhibited a strontium-90 concentration during 2014 of 7.2 pCi/L (a slight decrease from the 8.8 pCi/L observed in 2013).

A high-concentration strontium-90 plume is present in the vicinity of KE Reactor. The highest concentration portion of the plume formerly was represented by Well 199-K-109A, which had a strontium-90 concentration of 1,120 pCi/L the last time the well was sampled in 2008, and a historical maximum concentration of 18,600 pCi/L. This well historically exhibited strontium-90 concentrations greater than 5,000 pCi/L from 1996 to 2000. This well was decommissioned to facilitate demolition activities. About 120 m (390 ft) directly downgradient from 199-K-109A, the measured strontium-90 concentration continued to rise in extraction Well 199-K-141 to 54 pCi/L by mid-2014 (Figure 5-23), with the increase beginning soon after starting groundwater extraction at that well. The increased concentration in extraction Well 199-K-141 indicates part of the leading edge of the K East strontium-90 plume continued migration downgradient in 2014. With the addition of nondetect strontium-90 measurements from new Well 199-K-202, it now appears that the strontium-90 plume in this area is migrating from the location of former Well 199-K-109A toward extraction Well 199-K-141. The conditions observed in 199-K-141 most likely represent the leading edge of the strontium-90 plume in this area. This direction of plume movement is consistent with the current interpretation of groundwater gradient in this area.

Two wells in the K West region continued to consistently exhibit strontium-90 concentrations above the DWS of 8 pCi/L (199-K-107A and 199-K-34) in 2014. The maximum concentration of 56 pCi/L reported in late 2014 (199-K-34) was consistent with conditions measured in 2013. The concentration continued to gradually decline in Well 199-K-107A to 12.7 pCi/L in 2014 versus 16 pCi/L in 2013. The plume is inferred to be similar in size for 2014 in this vicinity. Concentrations are near detection limits in wells farther downgradient. Strontium-90 was not detected in samples collected from seeps at 100-KR during 2014.

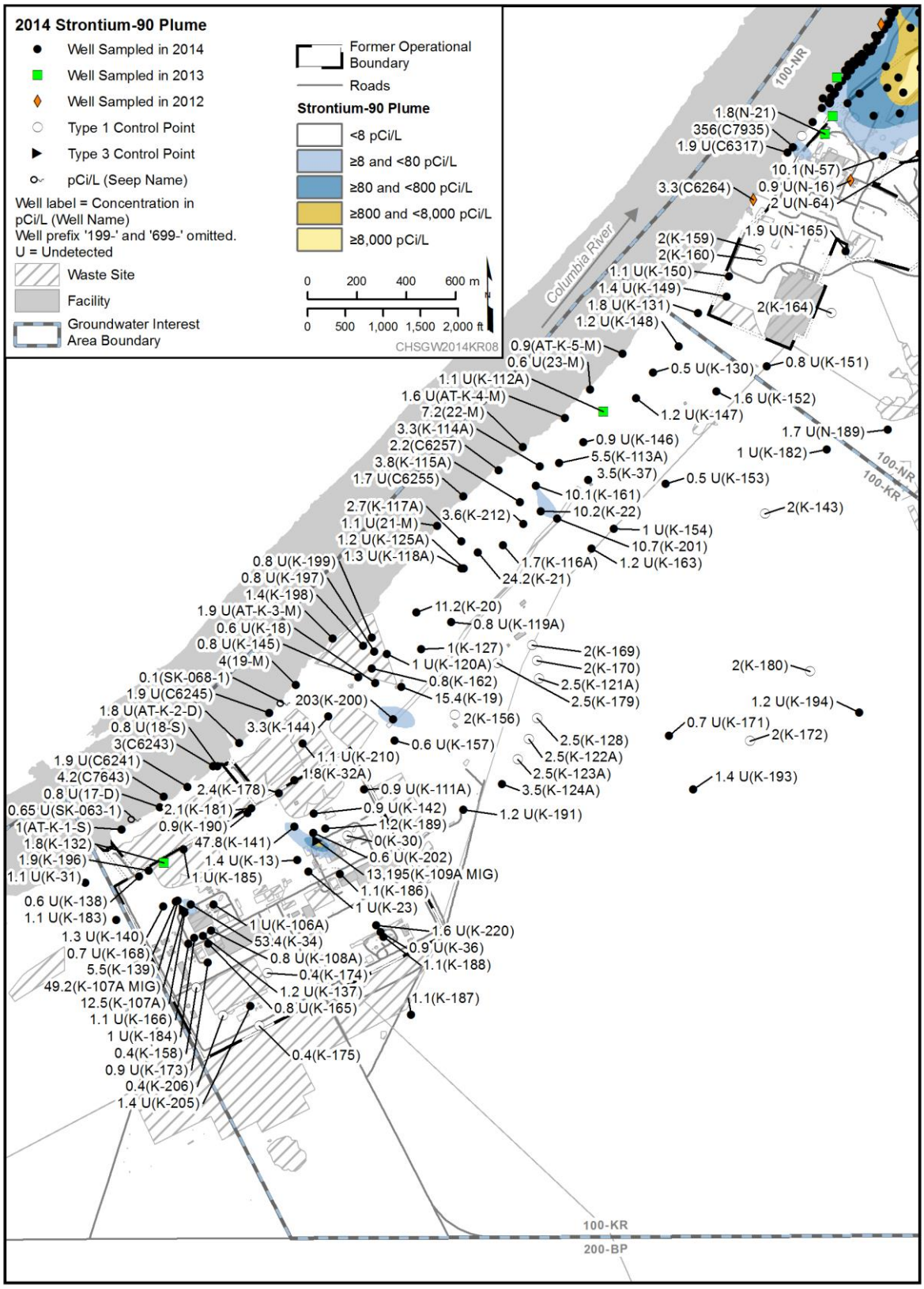

Figure 5-21. 100-KR Strontium-90 Plume, 2014

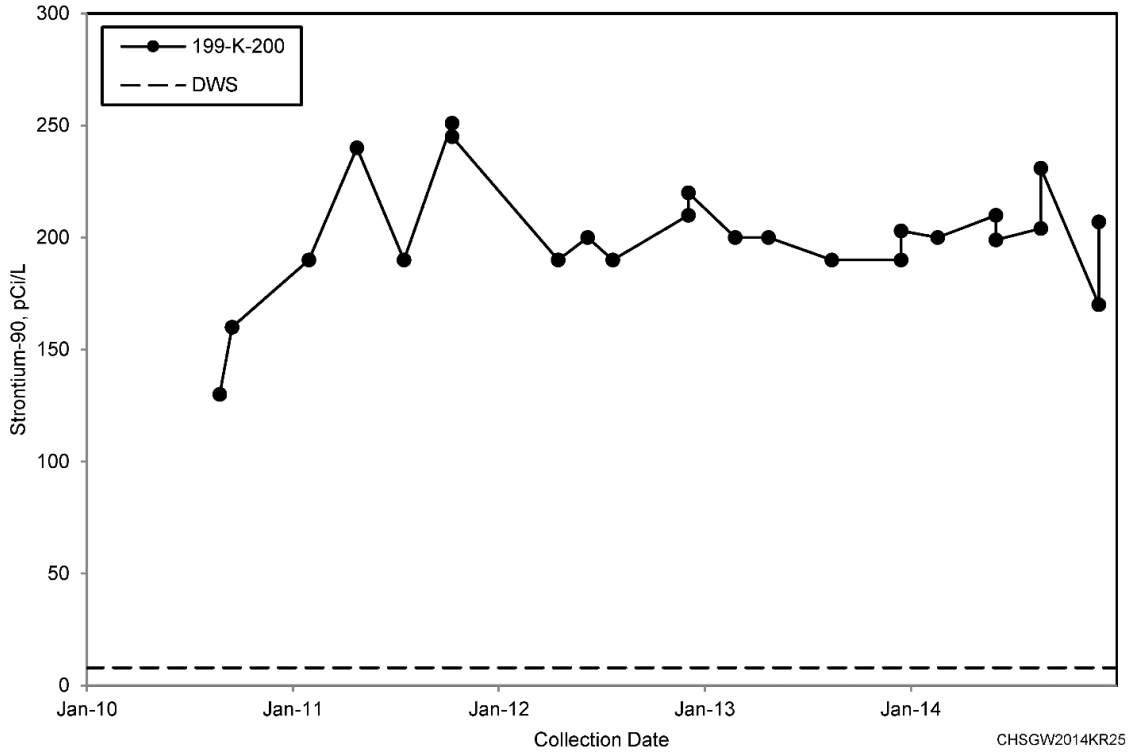

Figure 5-22. 100-KR Strontium-90 Data for Well 199-K-200, Located in Former 116-K-2 Trench

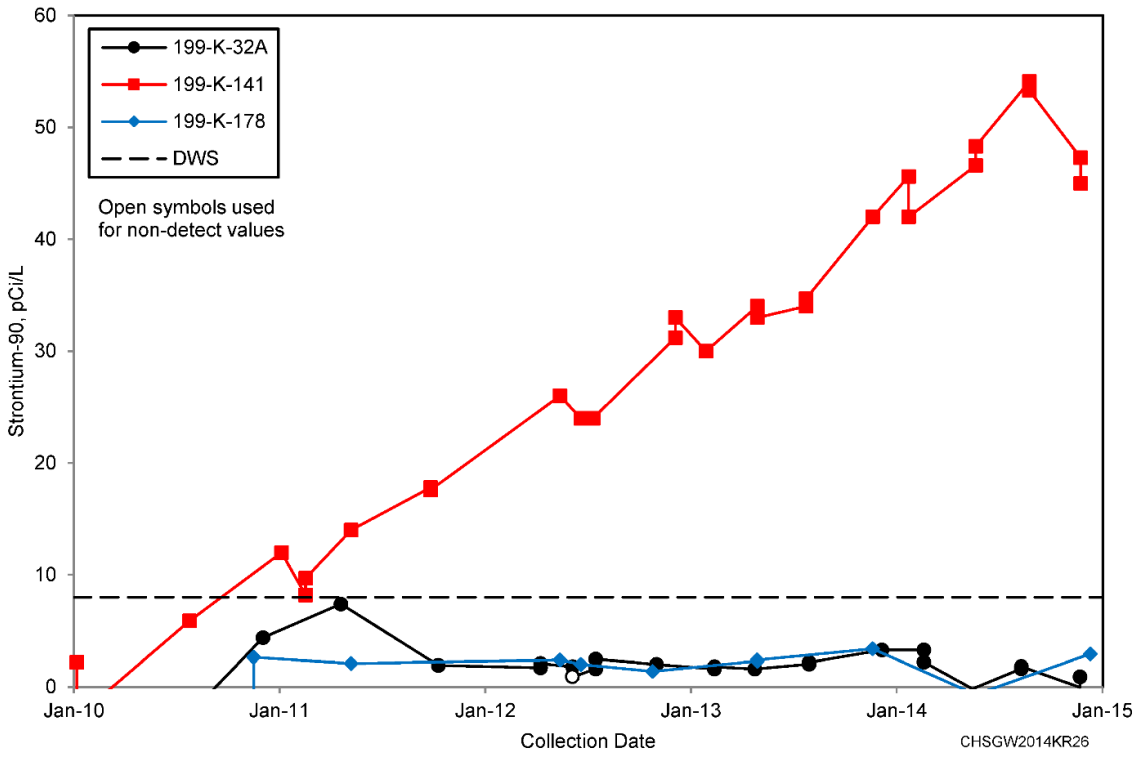

Figure 5-23. 100-KR Strontium-90 Data for Wells 199-K-32A, 199-K-141, and 199-K-178, Located Downgradient of KE Reactor

5.8 Carbon-14

Most of the carbon-14 in groundwater in 100-KR originated from historical discharges of reactor gas dryer regeneration condensate to the 116-KE-1 and 116-KW-1 Gas Condensate Cribs. Measurements of carbon-14 in gas dryer condensate collected at KE and KW Reactors during operation ranged from 2.9×10^8 pCi/L at KW Reactor to 1.04×10^9 pCi/L at KE Reactor. The gas condensate stream also contained tritium ranging from 3×10^9 pCi/L to 1×10^{10} pCi/L and ammonia ranging from 9,000 to 36,000 mg/L (HW-76258, *Reactor Gas Drier Condensate Waste – Decontamination Studies*).

To estimate the extent of carbon-14 groundwater contamination more accurately, extrapolations of historical carbon-14 concentrations from Wells 199-K-30 and 199-K-106A were evaluated. Plume migration was estimated in an area with no downgradient well. Values presented in the plume map (Figure 5-24) represent the extrapolated data. The highest residual carbon-14 concentrations in groundwater are associated with the KW Reactor, where the estimated maximum concentration derived from the extrapolation is approximately 39,500 pCi/L. The extrapolated concentrations associated with the KE Reactor are slightly lower, with the estimated maximum concentration of approximately 22,900 pCi/L. At both reactor areas, the resultant 2014 plume distribution exhibits an areal extent of concentrations exceeding the 2,000 pCi/L DWS that is similar to that inferred in 2013. Five wells in the K West region exhibited concentrations above 2,000 pCi/L in 2014 (199-K-106A, 199-K-34, 199-K-139, 199-K-132, and the new Well 199-K-204). These wells are located downgradient of the historical release site at the 116-KW-1 Crib and have exhibited the presence of elevated carbon-14 concentrations for most of the past 15 years. The carbon-14 concentration trends in these wells likely reflect migration of carbon-14 away from the inferred area of maximum concentration (greater than 30,000 pCi/L) immediately downgradient of the crib.

Monitoring results in 2014 from extraction Well 199-K-132 indicate that this well consistently exhibited carbon-14 concentration exceeding 2,000 pCi/L. Carbon-14 contamination in groundwater continued to be observed widely distributed over the KW Reactor vicinity at concentrations below 1,000 pCi/L.

A lower concentration carbon-14 plume exists in the K East region. The plume was formerly defined by Wells 199-K-29 and 199-K-30, which have been decommissioned. In 2010, Wells 199-K-29 and 199-K-30 had maximum concentrations of 3,120 and 6,900 pCi/L, respectively, which are above the DWS. These wells monitored conditions downgradient of the 116-KE-1 Crib waste site. As with conditions near the KW Reactor, the carbon-14 plume at the KE Reactor area appears to be migrating downgradient away from the source area. The extrapolated downgradient concentrations indicate that carbon-14 concentrations in groundwater, greater than 20,000 pCi/L, likely exist in the downgradient area where no effective monitoring currently exists. The carbon-14 plume at K East may not lie completely within the expected capture zone of the operating extraction wells of the KX P&T system. Well 199-K-202 exhibited a carbon-14 concentration of 1,560 pCi/L in 2014. New Well 199-K-203, located riverward of the 116-KE-1 Crib, exhibited carbon-14 at 6,230 pCi/L in a sample collected just below the water table during drilling.

Well 199-K-189, located downgradient of KE Reactor, continued to exhibit an increasing trend in carbon-14 concentration, with a maximum measured value of 2,950 pCi/L during 2014. Similar to the conditions observed at KW Reactor area, carbon-14 continued to be detected at relatively low concentrations in aquifer tubes near the 105-KE vicinity (below 500 pCi/L).

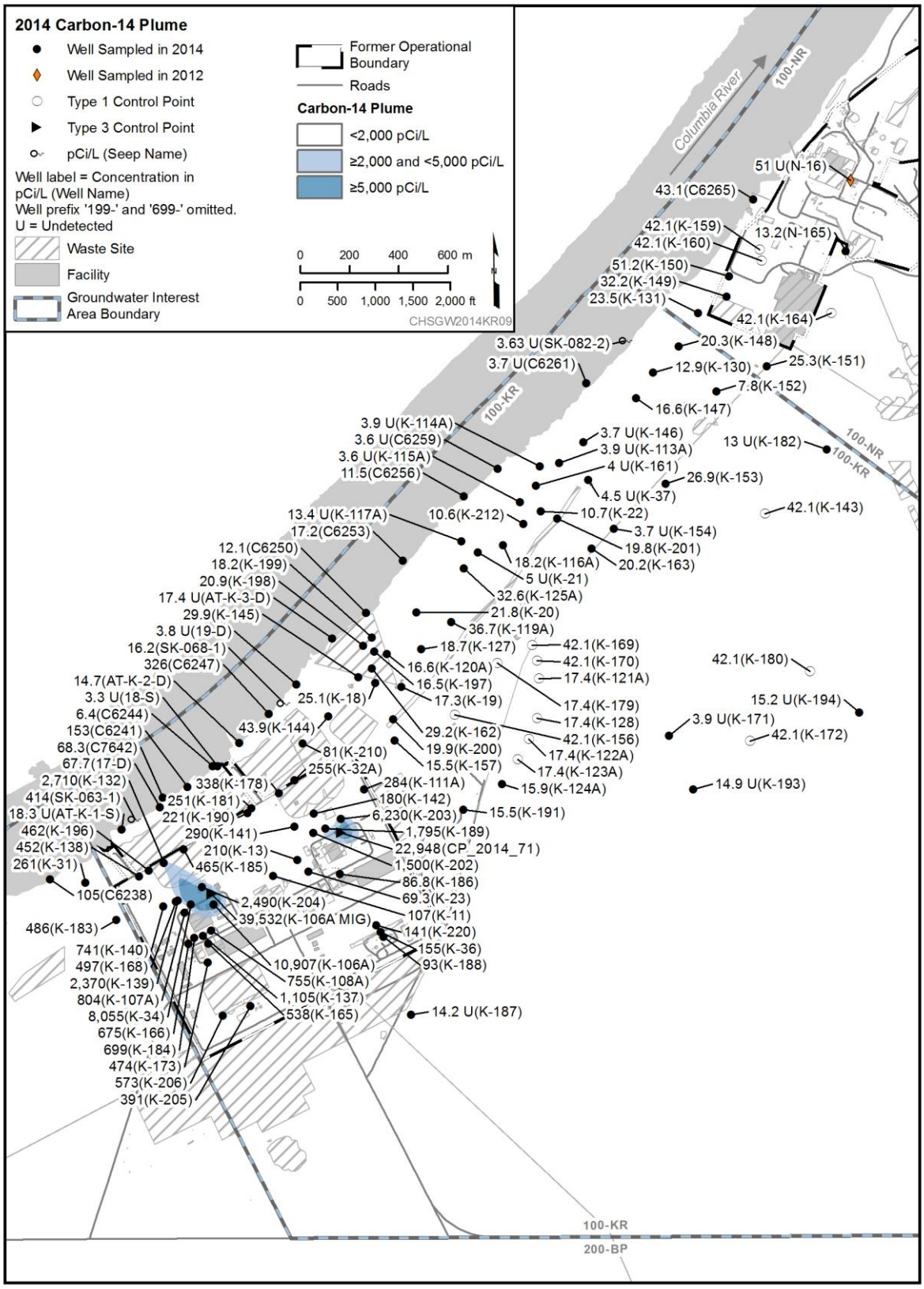

Figure 5-24. 100-KR Carbon-14 Plume, 2014

5.9 Trichloroethene

TCE continues to be detected in some 100-KR wells, primarily in the K West region (Figure 5-25). Seven wells in 100-K (199-K-132, 199-K-138, 199-K-139, 199-K-140, 199-K-168, 199-K-185, and 199-K-196) exhibited TCE at concentrations above the 5 µg/L DWS during at least one sampling event in 2014. The highest concentrations in routine samples in 2014 were 6.8 and 5.9 µg/L in Wells 199-K-185 (Figure 5-26) and 199-K-132 (Figure 5-27), respectively. The sources of TCE at 100-KR are not apparent but are likely related to the use of solvents during equipment maintenance activities; specific release points for TCE have not been identified at 100-KR. The TCE plume is poorly defined by the available measurements; there are relatively few wells in the general vicinity of the exceedance and this injects an element of uncertainty into interpolation of the plume contours. As with other contaminants at 100-KR Area, TCE is detected in effluent water at the KW P&T system. The annual average effluent concentration of 3.8 µg/L was assigned to the injection wells for the plume map interpretation. The relatively widespread occurrence of TCE in groundwater in the KW Reactor vicinity results in a dispersed plume in the KW vicinity that is slightly below the 5 µg/L DWS.

The primary source and release point(s) of TCE near the KW Reactor have not been identified, and historical maximum concentrations measured in monitoring wells were substantially larger than currently observed (e.g., 35 µg/L at Well 199-K-106A measured in 1995). The distribution of TCE in groundwater, as well as the actual maximum concentration, remains somewhat uncertain. At the near-river locations, TCE was detected in several aquifer tubes downgradient of the KW plume at less than 0.6 µg/L. Seep SK-063-1, located riverward of Well 199-K-132, exhibited TCE at concentrations below 1.0 µg/L during 2014; this is a decrease from the 2.38 µg/L measured in September 2013.

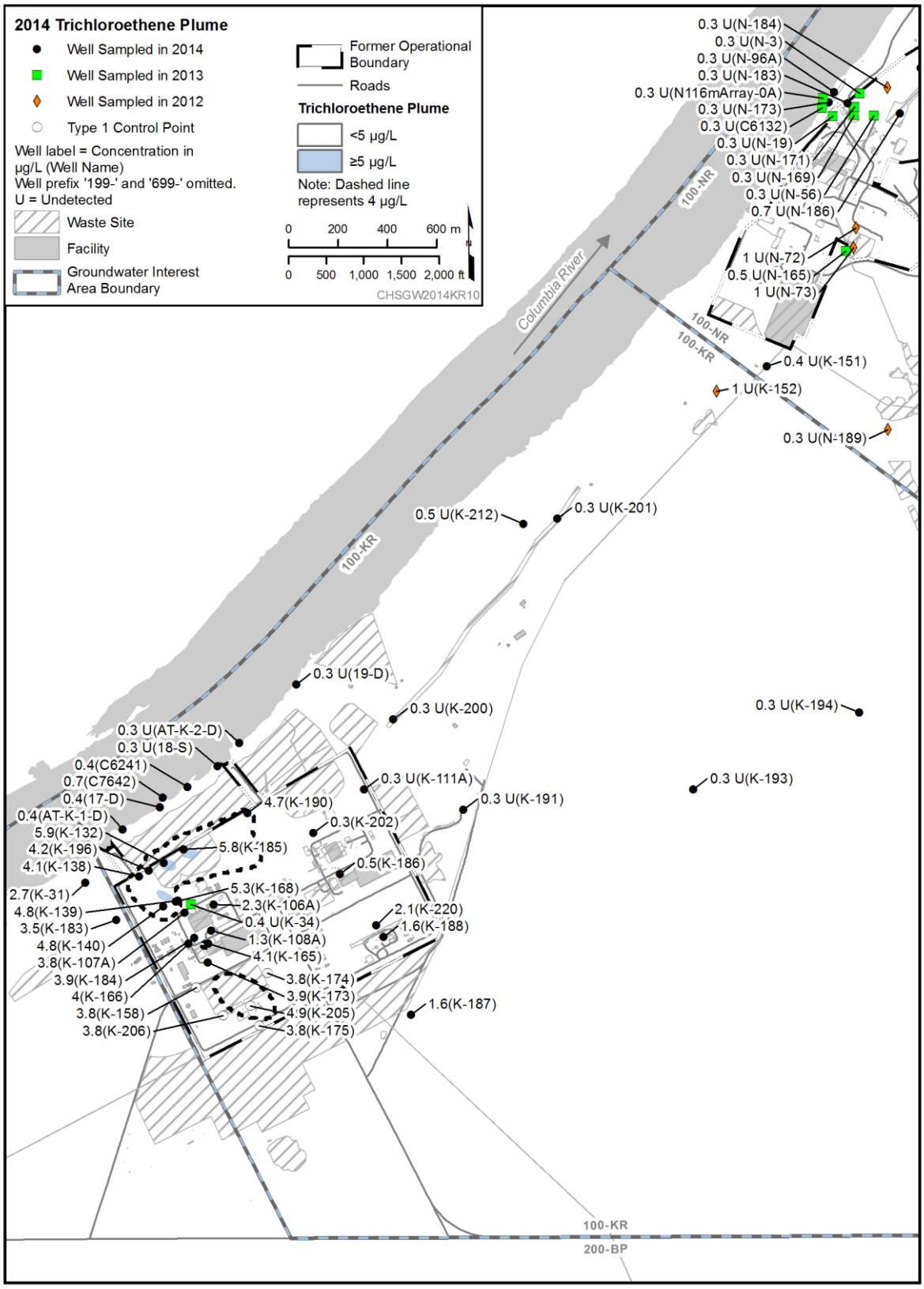

Figure 5-25. 100-KR TCE Plume, 2014

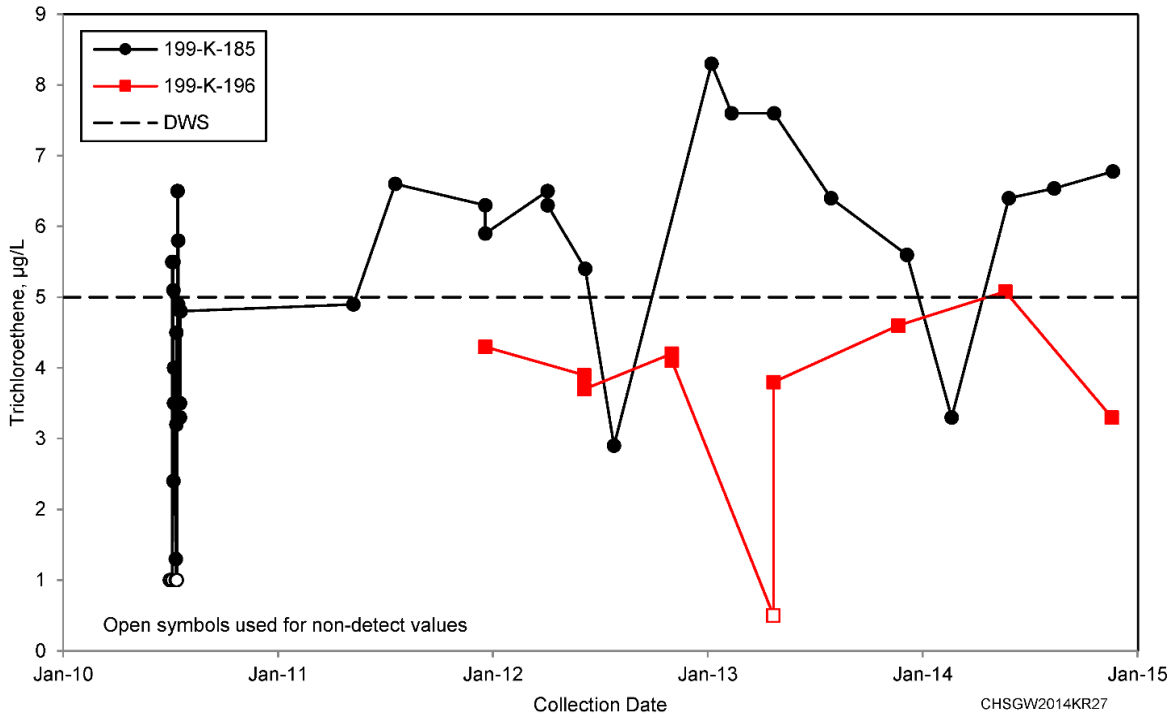

Figure 5-26. 100-KR TCE Data for Wells 199-K-185 and 199-K-196, Located Downgradient of KW Reactor

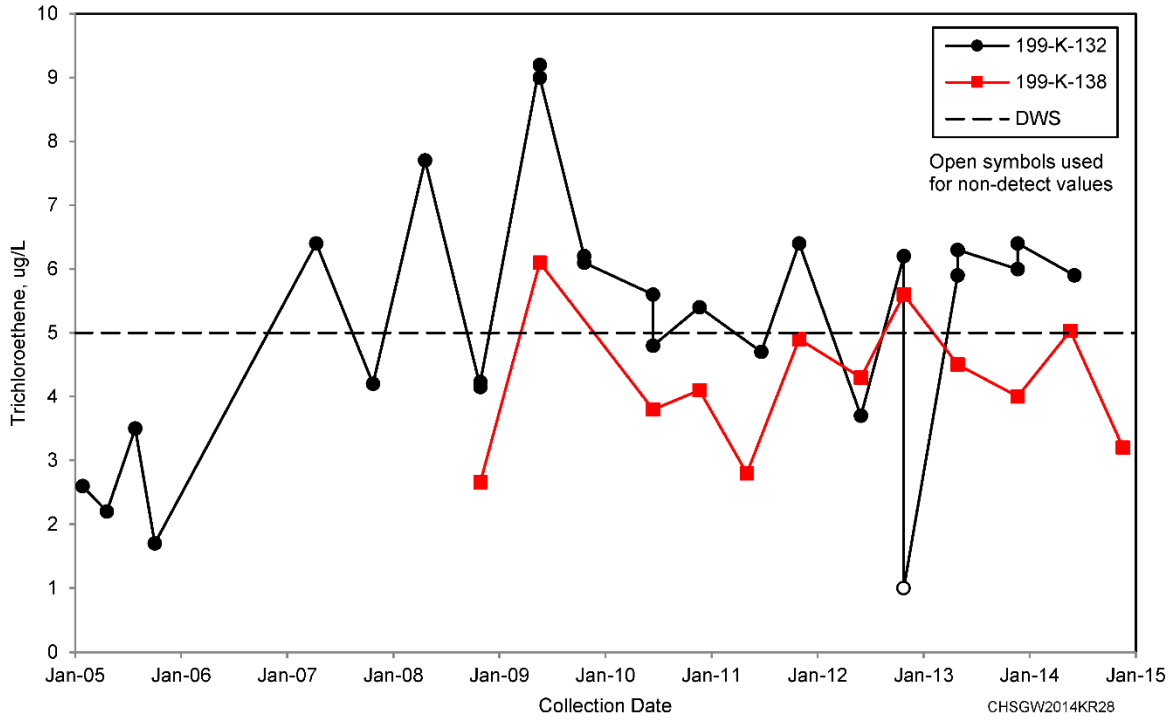

Figure 5-27. 100-KR TCE Data for Wells 199-K-132 and 199-K-138, Located Downgradient of KW Reactor

5.10 100-KR-4 Remedy

An interim action ROD for the 100-KR-4 OU was issued in April 1996 (EPA/ROD/R10-96/134). One of the RAOs identified in the interim action ROD is to protect aquatic receptors in the Columbia River from contaminants in groundwater. The interim action ROD included a preliminary estimated dilution factor of 1:1 for groundwater entering the Columbia River at 100-K, 100-D, and 100-H Areas under the assumption that dilution of groundwater with river water is expected before the groundwater would reach the aquatic receptor point of concern within the river substrate. This established and operational target for treatment system effluent at 20 µg/L for hexavalent chromium. For purposes of managing the interim remedial action, the working assumption is that groundwater at 20 µg/L at onshore, near-river monitoring locations will achieve the surface water standard of 10 µg/L at the point where groundwater discharges to the river (EPA et al., 2009).

Since the ROD was published, DOE has implemented three P&T systems to remediate hexavalent chromium contamination in 100-KR-4 OU groundwater and protect the Columbia River. All three systems, as listed below, operated in 2014 and are continuing to operate in 2015; 31 compliance and performance monitoring wells are identified for these systems:

- The original P&T system (KR-4), which began operating in 1997, focuses on contamination originating beneath the 116-K-2 Trench.
- The KX P&T system has two focus areas: one at the northeastern end of the 116-K-2 Trench, where the hexavalent chromium plume historically migrated toward 100-NR-2, and the other in the vicinity of KE Reactor facilities. The KX system began operating in 2009.
- The KW P&T system, which began operating in 2007, focuses on the hexavalent chromium plume at KW Reactor facilities.

Groundwater remedial action systems will continue to operate in the 100-KR-4 OU. These systems provide protection of the Columbia River from release of hexavalent chromium-contaminated groundwater that would cause an exceedance of the 10 µ/L surface water quality criterion and to maintain hydraulic containment of remaining hexavalent chromium plumes.

5.10.1 Pump and Treat

As of December 2014, 41 extraction wells and 18 injection wells were in service (Figure 5-28). Combined, the three systems are presently capable of treating about 8.2 million L (2.2 million gal) of groundwater per day. The combined P&T systems in 100-KR-4 removed 50 kg of hexavalent chromium from groundwater in 2014. Since 1997, the 100-KR-4 P&T systems have removed 797 kg of hexavalent chromium from the aquifer. *Calendar Year 2014 Annual Summary Report for the 100-HR-3 and 100-KR-4 Pump and Treat Operation, and 100-NR-2 Groundwater Remediation* (DOE/RL-2015-05) provides additional details.

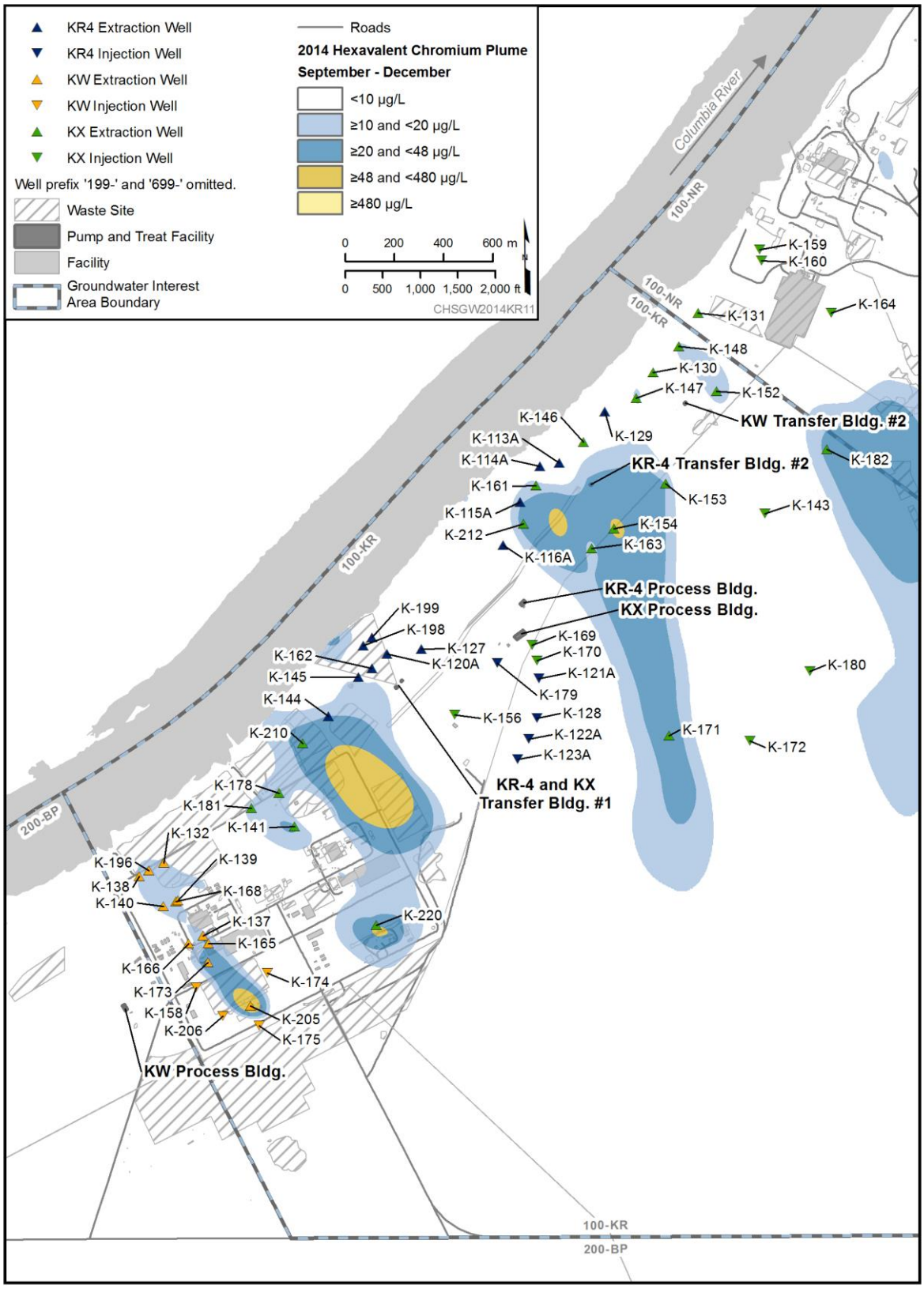

Figure 5-28. 100-KR P&T Well Locations

Under the current configuration, the 100-KR-4 P&T systems are demonstrating progress toward the interim RAOs (Table 5-2; Figure ES-5). Operation of the systems and containment of the plumes address the first and third RAOs defined by the ROD: (1) protect aquatic receptors in the river bottom from contaminants in groundwater entering the Columbia River, and (3) provide information that will lead to a final remedy. A summary of hexavalent chromium concentrations detected in compliance and performance evaluation wells during 2014 is provided in Table 5-3. Thirty-eight of fifty-eight wells identified in Table 5-3 exceed the 10 µg/L hexavalent chromium surface water quality criterion; twenty-four wells exceed 20 µg/L. Containment of the plume in combination with ICs also meets the second RAO: (2) protect human health by preventing exposure to contaminants in the groundwater. Operation and refinement of these remedial systems are also meeting the third RAO, which is to provide information that will lead to the final remedy. This included the addition of five extraction wells, one new injection well, and five new monitoring wells to the OU. Groundwater monitoring provides ongoing information regarding the nature, extent, and dynamic behavior of the groundwater plumes at 100-KR-4 OU.

Table 5-2. 100-KR-4 Interim Action P&T Systems, 2014

	KR4		KX		KW		Total	
Performance	**2014**	**1997–2014**	**2014**	**2009–2014**	**2014**	**2007–2014**	**2014**	**1997-2014**
Groundwater processed (million L/million gal)	527/139	7,280/1,925	1,198/316	5,773/1,524	579/153	2,916/771	2,304/609	15,969/4,221
Mass of hexavalent chromium removed (kg/lb)	5/11	373/833	26/57	200/497	19/43	224/537	50/111	797/1,868
Wells	**2014**	**2013**	**2014**	**2013**	**2014**	**2013**	**2014**	
Number of extraction wells	12	11	18	14	11	11	41	N/A
Number of injection wells	5	5	9	9	4	4	18	N/A
Hexavalent Chromium Plume Area	**2014**				**Change from 2013**			
Greater than 10 µg/L	2.1 km^2/0.8 mi^2				+12%			
Greater than 20 µg/L	1 km^2/0.4 mi^2				0%			

Table 5-3. Summary of Hexavalent Chromium Concentrations in 100-KR-4 OU Compliance and Performance Evaluation Wells for CY 2014

Well Name	Treatment System	2014 Maximum Cr(VI) (µg/L)
199-K-106A	100-KW	4
199-K-107A	100-KW	13
199-K-111A	100-KR4/KX	520
199-K-113A	100-KR4/KX	4
199-K-114A	100-KR4/KX	9
199-K-115A	100-KR4/KX	47
199-K-116A	100-KR4/KX	6
199-K-117A	100-KR4/KX	2
199-K-118A	100-KR4/KX	3
199-K-119A	100-KR4/KX	2
199-K-120A	100-KR4/KX	6
199-K-124A	100-KR4/KX	4
199-K-125A	100-KR4/KX	3
199-K-126	100-KR4/KX	12
199-K-127	100-KR4/KX	3
199-K-129	100-KR4/KX	5
199-K-130	100-KR4/KX	16
199-K-131	100-KR4/KX	10
199-K-132	100-KW	14
199-K-137	100-KW	27
199-K-138	100-KW	15
199-K-139	100-KW	20
199-K-140	100-KW	19
199-K-141	100-KR4/KX	27
199-K-142	100-KR4/KX	1.6
199-K-144	100-KR4/KX	25
199-K-145	100-KR4/KX	21
199-K-146	100-KR4/KX	27
199-K-147	100-KR4/KX	15

Table 5-3. Summary of Hexavalent Chromium Concentrations in 100-KR-4 OU Compliance and Performance Evaluation Wells for CY 2014

Well Name	Treatment System	2014 Maximum Cr(VI) (µg/L)
199-K-148	100-KR4/KX	19
199-K-149	100-KR4/KX	4
199-K-150	100-KR4/KX	8
199-K-151	100-KR4/KX	6
199-K-152	100-KR4/KX	39
199-K-153	100-KR4/KX	30
199-K-154	100-KR4/KX	80
199-K-157	100-KR4/KX	11
199-K-161	100-KR4/KX	43
199-K-162	100-KR4/KX	5
199-K-163	100-KR4/KX	26
199-K-165	100-KW	32
199-K-166	100-KW	23
199-K-168	100-KW	24
199-K-171	100-KR4/KX	55
199-K-173	100-KW	71
199-K-178	100-KR4/KX	25
199-K-18	100-KR4/KX	11
199-K-181	100-KR4/KX	16
199-K-182	100-KR4/KX	46
199-K-19	100-KR4/KX	8
199-K-20	100-KR4/KX	9
199-K-21	100-KR4/KX	11
199-K-22	100-KR4/KX	40
199-K-32A	100-KR4/KX	14
199-K-36	100-KX	316
199-K-37	100-KR4/KX	21
199-K-205	100-KW	3,280
699-78-62	100-KR4/KX	2

5.11 Atomic Energy Act Monitoring

DOE requires monitoring of environmental conditions, including groundwater, to document and understand impacts to the environment and to ensure that site-related nuclear contaminants do not result in unacceptable exposures to human and ecological receptors. This monitoring, generically referred to as "AEA monitoring" (after the *Atomic Energy Act of 1954*, which invokes the requirements) is conducted at selected locations and typically at concurrent timing with other groundwater monitoring activities required by CERCLA within the 100-KR-4 Groundwater OU. AEA monitoring at 100-KR is conducted in the vicinity of the fuel storage basins under PNNL-14033. The SAP for AEA groundwater monitoring is presently under revision and is expected to be completed in calendar year 2015. Revision of the AEA SAP includes review and identification of affected facilities and specification of data needs and monitoring locations, including those related to facilities at 100-KR Area.

The fuel storage basins in the KW and KE Reactor buildings were used from 1955 to 1971 to store irradiated fuel generated at the K Reactors, and from the late 1970s to 2004 to store irradiated fuel from the 100-N Reactor, along with other miscellaneous fuel recovered during remedial actions at other reactor areas. Each basin held approximately 4.9 million L (1.3 million gal) of shielding water that became highly contaminated with fuel residues and fission products (e.g., strontium-90, cesium-137, and tritium). In addition, each basin was originally connected to a drain system that included a combined crib and reverse well (waste sites 116-KE-3 and 116-KW-2) designed to receive water from a sub-basin drain system. These waste sites, as well as leaks around the KE Basin, contaminated the adjacent vadose zone and groundwater. The KW Basin has no documented leaks.

Fuel rods and debris were removed from the K Basins by 2008. The KE Basin, substructure, and crib were demolished in 2009. The reverse well associated with the 116-KE-3 Crib remains in place. Contaminated soil around the basin and crib was removed; however, more contaminated vadose zone soil remains at these locations. Prior to building demolition and soil remediation, downgradient groundwater monitoring wells around the KE Basin were decommissioned. The KW Basin has been emptied of fuel rods but remains water-filled and continues to serve as a depository for contaminated sludge from the KE and KW Basins. The KW Basin and the 116-KW-2 Crib and reverse well are scheduled for removal following removal of the remaining contaminated materials from the basin.

Based on reported contamination in the basin shielding water, analytes that may affect groundwater include tritium, carbon-14, technetium-99, strontium-90, and cesium-137. Tritium and strontium-90 in groundwater are considered to be the primary indicators of water loss from the fuel storage basin and crib system.

PNNL-14033 specifies groundwater monitoring requirements. Although the KE Basin no longer exists, the KW Basin remains in service, and a continuing sampling program is being maintained (Figure 5-29; Table B-90 of Appendix B). Previous leakage at the KE Basin and the use of dust suppression water during basin and vadose zone remediation warrant continued monitoring at downgradient wells for the near future. The groundwater monitoring network has been modified to account for wells that have been decommissioned. There are currently no groundwater monitoring wells remaining immediately downgradient of the KE Basin. Monitoring of the area for strontium-90 will continue using the existing wells. One new well, 199-K-202, was installed downgradient of this area in 2013. During 2014, two more monitoring wells were installed in the vicinity downgradient of the reactors; 199-K-203 and 199-K-204 were installed downgradient of 116-KE-1 and 116-KE-3 Cribs, respectively. DOE plans to place two characterization borings in this area (one each at the location of 116-KE-3 Crib and the historical release site from 105-KE Fuel Storage Basin [UPR-100-K-1]). Current plans include completion of those borings as wells.

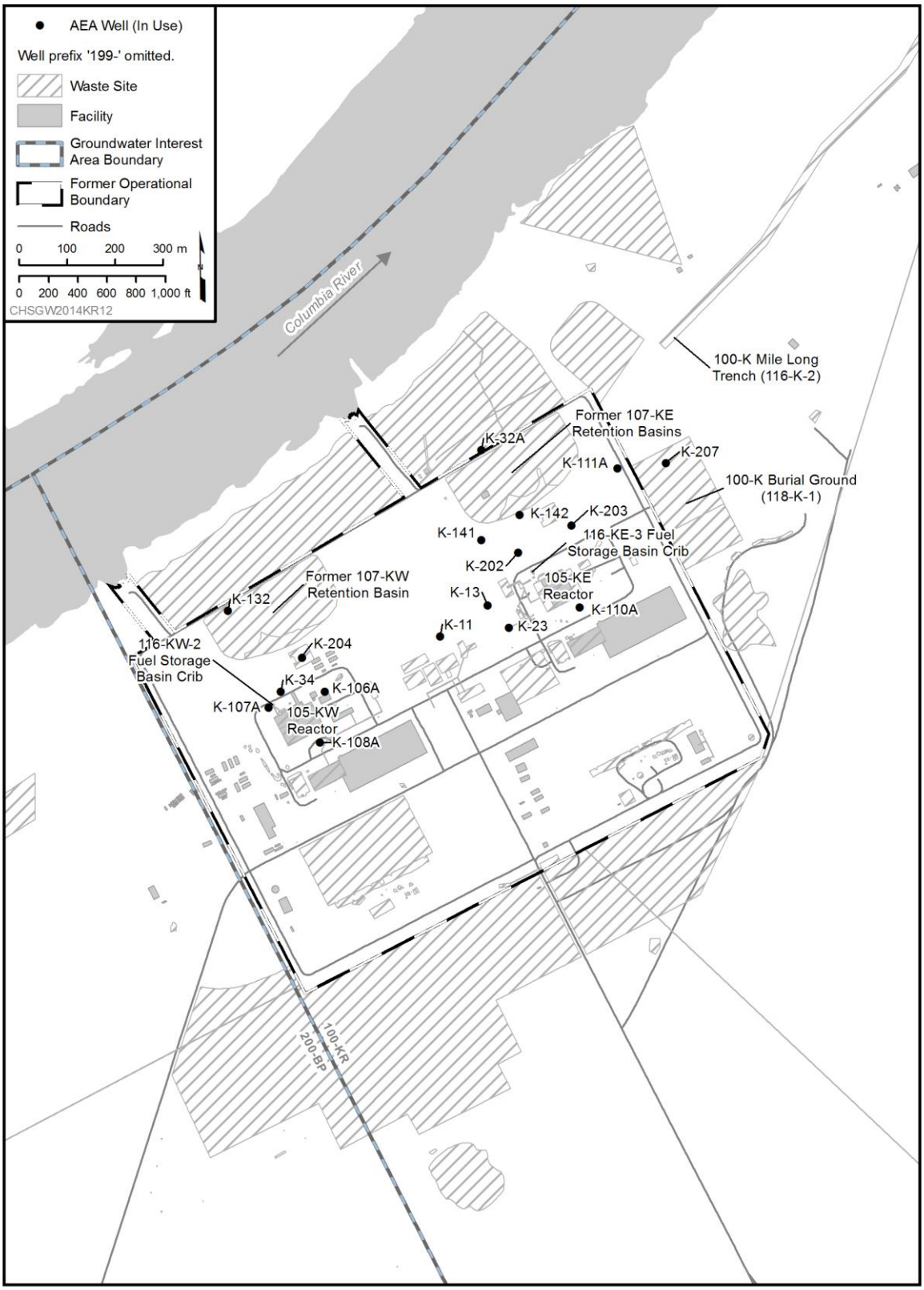

Figure 5-29. 100-KR AEA Well Locations

Tritium concentrations in wells downgradient from the KE Basins maintained previous trends in 2014, suggesting no new releases. Tritium was detected in a characterization sample from new Well 199-K-202 at 76,000 pCi/L. Well 199-K-111A exhibited an increasing trend since mid-2012; however, this tritium appears to originate in the vicinity of 118-K-1 Burial Ground, not the fuel storage basin, as indicated by the detection of elevated tritium in groundwater at new Well 199-K-207 (located within the burial ground footprint). Strontium-90 concentrations continued to increase in downgradient Well 199-K-141 (an extraction well for the chromium P&T system) in 2013. This contamination likely originated in the KE Basins or the adjacent 116-KE-3 Crib. In the past, higher levels of strontium-90 were detected in Well 199-K-109A, adjacent to the crib. Decreases in concentration at Well 199-K-109A between 1990 and 2008, when it was decommissioned, as well as the observed increase in Well 199-K-141, likely indicate downgradient movement of the plume. Strontium-90 was not detected in characterization samples collected from new Well 199-K-202. This indicates that the migrating strontium-90 plume is likely a narrow plume that lies between the location of the 116-K-3 Crib and 199-K-141. These conditions are consistent with migration of an existing plume and do not, of themselves, indicate any new release of contaminants to groundwater.

Tritium and strontium-90 concentrations in wells downgradient from the KW Fuel Storage Basin in 2014 were consistent with previous measurements and the expected migration of plumes downgradient, away from the source areas.